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AGRICULTURAL VALUE
OF THE
SEWAGE OF LONDON.

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THE

AGRICULTURAL VALUE

OF THE

SEWAGE OF LONDON

EXAMINED

IN REFERENCE TO THE PRINCIPAL SCHEMES

SUBMITTED TO THE

METROPOLITAN BOARD OF WORKS.

WITH

EXTRACTS FROM THE EVIDENCE OF CHEMISTS,
ENGINEERS, AND AGRICULTURISTS.

UNIVERSITY OF TORONTO

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THE
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CHAPTER I.

THE RISE OF THE PORTABLE MANURE TRADE.

The great metropolis is divided against itself. The ancient Corporation of London proper is at issue with the modern and more vigorous Metropolitan Board. The question between them is a money question. Subjects of less moment have, before now, been the cause of war between powers less numerous and wealthy; but in these law-fearing times the smouldering jealousy between these rival powers will result in nothing worse than vexatious discussions and correspondence.

After several years of scientific labour and the expenditure of millions devoted to turning the contents of the sewers of London into a distant part of the Thames, the Common Council have suddenly become convinced that the black, foul-smelling stream, which has so long rolled unheeded beneath their feet, is of enormous value, —a very Pactolus, which may be turned, without much trouble, into solid ingots of gold.

The Metropolitan Board, which owes its existence to the nuisance of a polluted Thames, and has from the first moment been oppressed with the responsibility of conveying the murky stream to a spot where it would be neither seen nor smelt by the inhabitants of London, takes a less brilliant view of the value of liquid manure prospects, and has, after three years' consideration, adopted, subject to the approval of Parliament, a plan which, in the first place, for ever secures the whole length of the Thames from pollution, and in the next, promises a rent contingent on the profits of the undertaking—which, although far below that promised by the projector patronized by the Common Council of London—will, if the scheme be moderately successful, amount to a sum not to be despised. The Corporation of London, through their Committee, contend that the Metropolitan Board are sacrificing a property worth millions per annum for a term of fifty years, and for an inadequate rent. The answer of the Metropolitan Board is that, after a long investigation and repeated invitations, they have adopted the plan that not only seemed the best for the public health and the most advantageous in an agricultural point of view, but also the only one that had any solid financial prospect of being executed at all. They say they have looked to men as well as measures.

Under these circumstances, it may be useful as well as interesting to present, in a condensed form, information now buried in Parliamentary Blue Books, Board of Health Reports, Farmers' Clubs' Discussions, and other equally bulky, scarce, and uninviting documents.

The value of sewage is essentially an agricultural question, and one which can only be ascertained by an examination of practical results on a large scale through a series of years. There is no axiom more absolutely received amongst experienced farmers than that the result of a single experiment in growing any particular crop is of little worth, because the quality of soil, character of drainage, depth of cultivation, warmth or coldness, rainy or droughty character of the season, and many other elements of success or failure must be considered before drawing any conclusion from an agricultural experiment.

There is another point that must be carefully remembered. Science has rendered great services to agriculture, yet no conclusions are less reliable than those of a man of science, whose experience has been limited to his study and his laboratory, and who ignores the profit and loss question,—a question which men of the highest scientific acquirements often pride themselves on despising. Farming is not one of the fine arts; it is a trade, and it is of little use to show that an extraordinary crop can be grown in a certain manner unless that manner will produce a profit.

As an example, one of the greatest authorities of the day amongst agricultural chemists is Baron Liebig. There are many who glibly cite Liebig's opinions, or supposed opinions, without being in the least able to understand or appreciate the importance of his investigations. And yet it is notorious that on several points of practical agriculture this eminent Professor has been flagrantly wrong; so wrong, that any farmer who had followed his advice would have inevitably been ruined. For instance, the experience of twenty years has proved that systematic drainage, originally suggested by Smith, of Deanston, and perfected by Josiah Parkes, is the greatest agricultural improvement of the age. On the continent of Europe, as in England, hundreds of thousands of acres of valuable land previously barren, unless in exceptional seasons, have been rendered capable of bearing fine crops; and sheep have been fed and fattened, where, before the application of drainage, they would have rotted. In fact, systematic drainage has not only rendered profitable the reclamation of waste land, but has more than doubled the value of retentive soils, which had been in cultivation for centuries. Yet when this system was first adopted, or rather indorsed with the authority of the Royal Agricultural Society, Professor Liebig believed and asserted that the result of thorough drainage would be to impoverish and eventually render barren the soil so treated. At the same time he introduced to public notice, through Messrs. Muspratt, the eminent manufacturing chemists of Liverpool, a patent mineral manure, which he promised should correct the effects of drainage, and enormously increase all crops. While the drainage proved a great success, the patent mineral manure proved a total failure. Still more recently, Baron Liebig has authoritatively stated that the soil of England, under the modern system of high farming, is becoming impoverished and reduced to the state of barrenness which afflicted the Roman States in the latter days of the empire; but challenged to point out a single example of this exhaustion in any parish or noted farm in England or Scotland, he has remained silent,—facts being notoriously opposed to the Professor's theory.

It is not for one moment pretended that Baron Liebig is not a great chemist, the author of important discoveries in agricultural chemistry; but attention is called to his mistakes in order to show that professors who confine themselves to their laboratories and little experimental plots, and who do not make themselves familiar with agricultural operations on a large scale, are not to be accepted as infallible authorities on agricultural operations where profit and loss are involved.

In like manner, garden experiments, performed by hand with a neatness and an accuracy which it is impossible to apply to the cultivation of acres, are very unsafe guides to a rent-paying farmer.

It is very easy to devise the mechanical appliances for damming up or diverting a rivulet, but when you have to deal with the shifting course of a mighty delta river, with a Nile or a Ganges, rivulet experiments are worse than useless.

The most striking difference between the modern British agriculture and the system described by Virgil and Columella, is to be found in the quantity of manure applied to the land. The Roman farmer collected a scanty quantity of manure from the dung of his labouring cattle, weeds, leaves, straw, etc.; but the British farmer of arable land absolutely manufactures manure of the richest quality by feeding stock under cover on cake, linseed, corn, and pulse, home-grown or imported, and, in addition, he imports manures, or the materials of which manures are manufactured.

At the commencement of the present century the trade of a dealer of manures was scarcely known. The only portable manures were rape-cake and bones, and their use was limited to a few districts. Farmers were content with the manure of cattle and sheep, which was not of the rich quality now produced by the free use of artificial food. In towns, water-closets had not been invented, and sewers were only used to drain off rainfall. The night-soil was carted away, and consumed by farmers and gardeners within reach of a day's waggon-journey, except where water-carriage was available. Within the last forty years a series of most important changes, affecting the value and distribution of night-soil, have taken place. On the one hand, as regards London in particular, the introduction of the water-closet and the construction of a system of sewers, into which all houses are compelled to drain, has turned nearly all the human excreta of the metropolis into liquid sewage. The market gardeners and farmers round London, being no longer able to obtain the contents of cess-pits, are obliged to be content with filling the waggons and carts that carry arable produce to London with the manure of stables, cow-houses, and the lairs of cattle for sale.

In proportion as the houses and streets of London came more under the complete system of house and street sewers assisted by a liberal supply of water, the Thames and all the other minor streams into which the sewers were discharged, became more and more polluted, until the nuisance became unbearable.

About the same time that water-closets came into ordinary use, and forced aside the regulations which had devoted sewers to rainfall alone, an important revolution commenced in the agricultural practices of the ever-increasing class of intelligent tenant-farmers. Until about 1840 the portable manure-machine most commonly used was a live sheep, used to feed on roots and cake, or pulse, distribute manure, and consolidate light land.

The importation of guano in 1835 was followed by the manufacture of superphosphate of lime in 1841 (first suggested by Baron Liebig). By slow degrees farmers became awake to the fact that a certain quantity of portable manure, composed of a mixture of guano and superphosphate, would, under ordinary circumstances, produce the same fertilizing effect as ten or twenty times the weight of farmyard manure ; and also that guano and superphosphate of lime would produce a *stimulating* effect and an increase of crops, which could not be obtained from the use of any quantity of farmyard manure alone. They also learned that the application of guano or ammoniacal manure produced the greatest effect on cereal crops,* and that superphosphate of lime was the most useful manure for root crops, such as turnips and mangold wurzel, etc. In practice, it has been found most profitable to make up manures for cereal and for root crops of a mixture of ammoniacal and phosphates ; the the first in larger quantity for corn, and the second for roots.†

The introduction of these portable manures enabled farmers—first, to cultivate in situations where the cost of carting ordinary manures had been too heavy to be profitable ; secondly, to stimulate their crops at particular seasons by drilling in or top-dressing with a suitable artificial manure.

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* An application of about 30*s*. worth of guano as a top-dressing being pretty sure (on suitable soils) to produce an increase of a quarter per acre in a wheat crop.

† 'All substances containing nitrogen may be regarded as special 'manures for cereals and grass crops. Their especial function is to 'promote the growth of cereals. Hence the remarkable effect follow'ing the use of guano; for this is a manure rich in nitrogen, and in 'consequence of the large amount of ammonia it contains, produces an 'extremely beneficial effect on the wheat crop. Bones consist principally of phosphate of lime. Phosphate is most beneficial for root 'crops, but it is required for all agricultural produce. There are also 'potash and soda largely required by all agricultural plants, and are 'absolutely required for their existence. Now, the great value of 'artificial manures depends on the fact that they *concentrate* all these 'important fertilizing materials.'—*Dr. Voelcker's Lectures to Farmers*, 1857.

For example, in the ordinary case of a root crop to be followed by a wheat crop, a farmer cultivating on high-farming principles would begin by ploughing in fourteen or fifteen loads of well-made farmyard manure—manure from animals fed on plenty of cake, beans and corn, with their roots and chaff. This manuring with farm manure is a most important operation on stiff soils, because the solid farmyard manure not only fertilizes and nourishes the soil, but has a mechanical effect in making it more loose and friable, and able to receive the benefit of rain and air. After ploughing in the farmyard manure at the suitable season, according as the land was intended for turnips or mangolds, the horse-drill is set to work. This implement, called into existence by portable manures, ingenious deposits in regular rows, and by one operation, the seed of the roots required, and at a distance of a few inches, a small dose of appropriate portable manure.

When the seed vegetates, the roots instinctively turn toward the portable manure, are stimulated by it into quick healthy vegetation, and should no adverse unusually dry season occur, continue to thrive and flourish on the stores of farmyard manure. The root crop having been in due season removed, and the ground again prepared for seed, without a second dressing of manure, the wheat seed is sown, and when the plant has made a certain progress, a top dressing, chiefly composed of guano, is sown broadcast. In an exceptionally dry season the benefit of this top-dressing will be lost.

It is absolutely necessary that those who are attempting to arrive at the value of town sewage should understand that the qualities which render portable manures, whether ammoniacal or phosphatic, valuable, are their concentrated strength and portability, and these create a great demand at highly remunerative prices.

The manure which contains all the elements of fertility is the farmyard manure, made under cover by horned stock well fed on chaff, roots, corn, oil-cake, linseed, pulse of some kind, and in due season mixed with the manure of the corn- and bean-fed horses and well-fatted pigs. No artificial compound has yet been made which, for ordinary purposes, can economically equal farmyard manure made as above described.* But it has one disadvantage, its bulk being from ten to twenty times as heavy as the guano containing the same amount of ammonia,—that is to say, of corn-producing fertility.

It is a noteworthy fact, that the farmers who manufacture the richest manure, who spend the largest sum per acre in purchasing cake, Egyptian beans, etc. for their cattle, are also those who are the largest customers for portable manures composed of guano and superphosphate. Farmyard and portable manures have each their uses,—one does not supersede the other. The time has not yet arrived, predicted by Baron Liebig, when the fertilizers of a thousand acres can be carried in the pocket of a shooting-jacket.

One of the early effects of the use of portable manures was the introduction of the farmer to the chemist. The active portable manures produced by respectable manufacturers were imitated by a crowd of impostors, who professed to sell the value of a sovereign for five shillings, or less. Thus purchasers were driven, in self-defence, to consult the analytical chemist, in order to ascertain that they had their money's worth. The chemist was thus drawn from his study and dragged over ploughed fields, obliged to sit in farmhouse-parlours and listen to prejudices, opinions, and experience of farmers, who only value scientific assistance as a means of paying rent and making a profit.

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* 'It is the complexity of the composition which renders farmyard 'manure so valuable and indispensable to farmers. It is a perfect 'manure, because it contains all the elements necessary for supporting 'a healthy and vigorous growth of the plant, and it is a universal one, 'because it universally produces those effects. *It is also valuable because it produces mechanical effects. The important mechanical effects of long dung on clay soils are attended with beneficial results, which cannot be attained by any artificial manure.'—Dr. Voelcker's Lectures to Farmers.*

The 'Journal of the Royal Agricultural Society' contains many papers from the pens of Professor Way and Professor Voelcker, which show the value of free communication between the chemist and the rent-paying farmer. The farmer has been instructed and enlightened; the chemist has reduced his theories to a rent-paying test.

The first cargo of Peruvian guano was imported in 1835, but the artificial manure trade dates from not earlier than 1842–3, when the manufacture of superphosphate was commenced on a large scale. It is a sufficient proof that our farmers are wanting neither in intelligence nor enterprise when a profit is to be realized, that within ten years an enormous trade has been created in nitrogenous and phosphatic manures, and also in the new and costly implements for distributing them.

The trade has gone on increasing ever since, and its extension seems only limited by the price at which it is possible to deliver the approved portable manures.

CHAPTER II.

ORIGIN AND PROGRESS OF LIQUID MANURE THEORY.

Human manure has been in use as a fertilizer from the earliest ages. There can be no dispute about its value, where the bulk and weight do not swell too high the cost of carriage. Its use in this country in the shape of night-soil, now that portable manures have been introduced, is generally limited to situations within the reach of the vehicles which, bringing garden or agricultural produce to market, can take back a return cargo from cesspits as well as stables and cow-bins,—a distance that may be estimated at from fifteen to twenty miles from a great town.

The idea of making systematic use of liquid sewage, and in agricultural operations, originated with Smith, of Deanston. He had made many experiments in the use of solid night-soil from the privies of his workpeople when he was a cotton-spinner, and had grown extraordinary crops; his wheat crops, however, being infinitely richer in straw than in grain. His pursuits as an agriculturist and a cotton-spinner not proving successful, perhaps from his extraordinary taste for experiments, he became a Commissioner under the first Board of Health, created by Mr. Edwin Chadwick, and in that capacity visited Edinburgh in 1844. There he found, in active operation, the sewage meadows which had been established many years previously, and which still continue the best example of the profitable application of sewage to agriculture.

The putrid sewage from part of Edinburgh, flowing from the hill on which the city stands, runs through meadows with great force, the stream turning a water-wheel, which raises the liquid manure about 30 feet, whence it flows by gravitation over other meadows with admirable results. Five and six crops are obtained yearly, and part of the ground consisting of pure sea-sand, a few inches above the level of the tide, originally absolutely worthless in an agricultural point of view, has been raised to an average annual value of £26 per annum, and pays taxes on an assessment of not less than £22 per annum.

This capital example suggested to Smith's ingenious mind the idea of utilizing for agricultural purposes the sewage of all the towns of England, and especially of all the towns sewered under the control of the Board of Health. From the sum to be obtained from liquid manure he calculated that a rental would arise, sufficient not only to defray the cost of sewering at own, but to execute many public improvements.

He proposed to irrigate grass-land on the water-meadow system, but suggested the distribution, by hose and jet, "under a pressure of 150 feet of altitude, to a number of convenient points in the farm where it is to be used, to tillage land on which water cannot be distributed by irrigation, and on which the results have hitherto not been found so profitable as on grass." He then proceeded to calculate that liquid sewage was worth half as much as guano, and that therefore the sewer water, as he calls it, of every town was worth £1 a head.

It has been acutely observed by a contemporary writer, "that in 1843–8 these assumptions and speculations of Smith of Deanston were rational and plausible; the practice of agricultural chemistry was almost unknown; he had no experience to guide him." In the years that have since elapsed, the progress of agricultural chemistry and experience on many liquid manure farms have materially diminished his elements of profit, by proving the essential difference in the possible application of bulky, weak, diffused manures, and concentrated, portable manures.

It is well ascertained now that there is no sort of analogy or possible comparison between liquid sewage and portable concentrated manures: each has its useful place, but beer and brandy are not more unlike in their effects and constituents.

After twenty years' experience we have not arrived further in the application of sewage than the lesson taught by the Edinburgh sewage meadows,—viz., that on a suitable soil in a suitable situation enormous crops of grass, natural and artificial, may be obtained by the application of sufficient quantities of liquid sewage. But no example can be cited of the *continuous and profitable* application of liquid manure to cereal or root crops.

On the foundation of Smith of Deanston's Reports, Mr. Edwin Chadwick, for the Board of Health, constructed a theory with which Smith would by no means have agreed; but he was not consulted by those who then ruled over the health of towns.

The theory was, that liquid manure was, under all circumstances, preferable to solid manure; that liquid sewage might be profitably applied to all crops and to all soils; and that it could be most profitably applied, forced by steam power through subterranean tubes of iron or earthenware.

This theory, with detailed instructions for arranging the pipes and pumps of sewage manure farms, was circulated in thousands of the Board of Health Blue Books throughout the United Kingdom, diffused in lectures, speeches, and articles in popular periodicals, and backed by all influence of the engineer inspectors of the Board of Health, to whom the control of towns to be supplied with sanitary works by the Board was confided. It was one of the instructions of the Board that every system of sewers should be brought to one outfall, with the view of applying the sewage to agricultural purposes; and all the many towns sewered under the control of the Board of Health were so arranged.

The authoritative announcement of the valuable manure elements contained in such a waste substance as town sewage, led to numerous experiments, and brought out endless joint-stock schemes.

Men of fortune of an enterprising turn, with a taste for agriculture, accepted the tempting theory that liquid manure was superior to and could supersede all solid manures; and a number of farms in England and Wales were underlaid with pipes and provided with steam-engines and pumps and hose at vast expense.

In Scotland, too, very perfect examples were provided, one by Mr. Telfer, the other by Mr. Kennedy, which for a few years were continually cited as instances of the success of liquid manure applied by jet and hose with steam power. Mr. Telfer had a dairy farm which was a model of beauty, order, cleanliness, and exact accounts. His butter, sent all the way from Scotland to London, sold for a penny per pound more than the best English butter. Both he and Mr. Kennedy grew extraordinary and repeated crops of Italian rye-grass, which were the subject of several sensational speeches at farmers' meetings by Mr. Mechi. Mr. Mechi himself piped his farm, provided himself with a steam-engine, and announced his intention of feeding his live-stock, cattle, sheep, and pigs, under cover on boards without straw, of reducing his straw to chaff for the consumption of his beasts, and using all the manure thus made in a liquid form. Tiptree was to dispense with solid manure and top-dressing for all its crops, and rely for fertility on the supplies of the jet and hose. The hose and jet farm of Mr. Neilson, a Liverpool merchant, was the constant subject of the eulogy of the Board of Health Reports; and Mr. Littledale, another Liverpool merchant, fitted up a dairy farm on the same plan. In Norfolk, Mr. Chamberlaine, a wealthy retired tradesman from Norwich, purchased an estate, and laid it out at extraordinary expense, under Mr. Mechi's advice, with steam power and pipes; and there were other establishments which it is not worth while to name, none of them being supplied with town sewage, all, with one exception, working after the plan recommended by the Board of Health —by steam power, and not by gravitation—and all attempting to cultivate all crops with liquid manure. The exception was the Rev. Mr. Huxtable, who once made as much sensation as Mr. Mechi—undertook to teach plain farmers their business, and all the mysteries of agricultural chemistry which he had just learned. Mr. Huxtable employed gravitation to distribute liquid manure.

But it may safely be asserted that not one of these liquid manure farms paid a rent. Mr. Neilson became a drainage inspector, and gave up farming; Mr. Telfer failed; Mr. Kennedy, after sinking an enormous sum on Myremill, disappeared from the sensational world of agriculture; Mr. Huxtable, most extraordinary of all, not only found out, but acknowledged his mistake in attempting "to teach his grandmother to suck eggs," gave up the liquid system and his idea of dispensing with solid manure, and limited his operations to a few acres of home farm. Mr. Chamberlaine the Norwich gentleman's attempts at model farming proved disastrous, and eventually the pipes were taken up and sold for old iron. Mr. Littledale confined his operations to growing rye-grass for his fancy dairy, grew corn with solid manure and top-dressings of guano, and never pretended to make a profit. His pipeshow-farm was his amusement, not a serious investment.

As to Mr. Alderman Mechi, at some mysterious date he took to the ways of the Norfolk and other *retrograde* farmers he had often denounced, used his stock to tread his straw into manure, grew his mangolds with liberal loads of solid long-straw manure and dry superphosphate, had his wheat to follow, and used his costly liquid manure apparatus as a gigantic watering-pot.

But Mr. Alderman Mechi, as a witness on the sewage question, must have a section to himself.

As to the utilization of sewage, the extraordinary influence used by the Board of Health, and the tempting example of Edinburgh, had, in 1864, after twenty years' agitation, only produced the following examples:—Alnwick, Croydon, Carlisle, Malvern, Rugby, Tavistock, and Watford.

Considering that during this period of twenty years many millions sterling have been laid out in agricultural improvements by both landlords and tenants, in deep drainage, in newly-invented implements, in costly portable manures; considering that in that period not only have the drill and the iron-wheeled plough, but the steam-driven threshing-machine, the reaping-machine, and even the steam cultivator, more or less superseded inferior implements and machinery in every county of England; considering that sewage contains within a certain bulk nearly all the elements of fertility—all, indeed, when applied to grass crops; it is evident that there must be some obstacle, commercial or mechanical, to its use, much more powerful than the supposed ignorance and prejudices of the farming population.

The prejudice against the use of a foreign manure, against substituting a drill-machine for the broadcaster, against replacing the flail by the threshing-machine, against using an "American" reaper, were, within much less than twenty years, apparently insurmountable; but example and success have carried all these implements into the most benighted counties, and raised up great and profitable English establishments for their manufacture. Thousands of skilled mechanics, at Lincoln, at Ipswich, at Bedford, at Saxmundham, are employed in satisfying the mechanical demands of the British farmer, which twenty years ago were chiefly supplied by the village blacksmith.

It is not necessary to have an intimate knowledge of agriculture, of chemistry, or of mechanics, to prove that in this eminently speculative country, had the application of sewage to agricultural purposes been as easy and as profitable as some loud-talking and fluentlywriting people pretend, it would long since have formed the foundation of more than one joint-stock company.

With respect to the value of sewage, great as it may be when conducted to a suitable soil, it is worth nothing until it has been removed from the city—where it is a nuisance—to the land, where it will grow crops. For this reason, all comparison between the value of sewage and the value of guano are simply absurd. Guano is saleable the moment it arrives in port; there is a price current, and at a reduction of two or three pounds a ton on that price it would be easy to sell, even before it was landed, an additional fifty or even a hundred thousand tons. The merchant has no difficulty in storing it, neither has the farmer. If it is not required this season, it will lie in the manure-shed until next. But the value put upon sewage by certain persons (a value entirely disclaimed by agricultural chemists) depends on the chemist doing something which it is impossible to do. If the fertilizing constituents of the solid and liquid sewage of London could be taken out and dried without any expense, they would be worth a sum variously estimated at from one and a half millions to three millions. But as the process is impossible, any calculation founded on this estimate is a waste of time. Before the sewage can be made worth anything, it must be conveyed to a place suited to receive it, within the reach of persons prepared to purchase manure largely diluted with water. To those who want it, sewage has a certain value; but to those who do not want it, it is worse than valueless, because it can neither be stored nor got rid of.

There are many rich mineral deposits of great intrinsic value which are worthless in consequence of the cost of bringing them into a marketable condition; for instance, the copper-mines of Lake Superior, many mines in South Australia, the fine iron ore of a most valuable character found on the shores of Taranaki, New Zealand. There are coals in France lying so deep that they will not pay for working. When the father of the late Mr. Russell, M.P., bought the Brancepeth estate and castle, the coal-mines known to lie under the estate were valued at nothing, because it would not pay to cart them to the coast; but railroads have since made these coal-mines worth more than £10,000 a-year. A more familiar example of the difference between a portable and a bulky manure may be found in the Metropolitan Market. Before this market was open, the Common Council Committee, knowing that the manure of stables and cowhouses was readily purchased by market gardeners, naturally calculated on a considerable revenue from the sale of the well-fed cattle, sheep, and pig dung of the market. But when business commenced, and it was necessary that the muck of Monday should be cleared away before Thursday's market opened, the committee found, that, so far from being able to sell the vast accumulation, it was necessary to pay a contractor a large sum to remove it. Had the market been held only once a week, they could have sold the market sweepings for something considerable; but the bulk and the necessity of bi-weekly clearance defeated the Common Council's committee's calculations.

London sewage continuously applied to the wrong soil would turn a garden into a morass, but applied to the right soil it will turn a desert into a garden; it is therefore absurd to put a value on what requires so large an expenditure and such special arrangements to give not only its highest value, but any value at all. Dr.

Voelcker, who at the Royal Agricultural College used his opportunities for experiments on actual cultivation, observes in his Lectures, 1857, long before any question arose as to the value of London sewage:—

> '*Liquid manure* is the worst form of manure you can use 'on some land, while on others it is the best. If you have a 'soil that contains little else but sand, apply liquid manure; not 'merely water, but the constituents of farmyard manure in a 'liquid state. Instead of doing it all at once, it should be 'applied in small quantities three or four times, for it gets to 'the plant in the more prepared state, which in poor sandy 'soils is attended with no inconvenience, but it would be very 'inconvenient to apply liquid manure on a stiff retentive soil, 'where an excess of water ought to be drained off. *A sandy 'soil drains itself.* By applying food in the form of liquid 'manure to heavy land, you injure it in a mechanical way. '*At any rate, liquid manuring does not answer on clay soils.*'

The value of sewage will vary enormously according to the situation of the town and the nature of the surrounding soil, and the quantity of water-supply. Every gallon per head above four gallons reduces the value of the sewage. What comparison can there be between the value of the sewage of a town so placed on a hill as to be able to deliver by gravitation for several miles round on a light and porous soil, and the sewage of a town situated on a river-valley surrounded by stiff, retentive soil, and compelled to resort to steam-power?

The time has passed for theorizing on the value and use of sewage. There is in existence a sufficient mass of reliable evidence to point out the best mode of disposing of the sewage of London, keeping in view three important conditions:—

1. That 277,000 tons, amounting to about ten million

cubic feet, and capable of filling a lake seventy-five acres in superficial area, and three feet deep, must be received and consumed by the contractors every day in the year.

2. That the whole course of the Thames shall be secured from pollution, and the inhabited districts from even the chance of a nuisance.

3. That the Metropolitan Board should obtain, without involving the ratepayers in any risk, a fair, full rent, increasing as the field for the use of sewage is increased.

CHAPTER III.

EVIDENCE OF CHEMISTS, ENGINEERS, AGRICULTURISTS, ETC.

The Blue Books containing the proceedings before the Committees of the House of Commons, presided over by Dr. Brady in 1862, and Lord Robert Montagu in 1863-64, contain a mass of the latest evidence on the value and application of sewage manure. From this evidence it is proposed to select and condense the opinions of those agricultural chemists, engineers, and agriculturists, whose knowledge and experience entitle them to weight. It would be a waste of time and space to dwell on the evidence of those who only repeat what they have read in the Reports of the Board of Health,—reports prepared before we had practical experience to guide us.

Evidence of Agricultural Chemists.

Dr. Augustus Voelcker is the Consulting Chemist of the Royal Agricultural Society, and was for many years Professor of Chemistry at the Royal Agricultural College, Cirencester. It may safely be asserted that he has the confidence of the farmers throughout the West of England, with whom he was in constant communication, and to whom he delivered lectures on chemistry full of practical suggestions.

Dr. Voelcker says—

'Liquid manure may be applied with great advantage on 'light porous soils, but on heavy clay-land it cannot be applied 'with advantage; even when more concentrated than sewage, its 'application is attended with loss to the person who applies it. 'Dry solid manures, even when poor, will have a mechanical 'as well as chemical effect. The poorest straw-manure ploughed 'in will keep the land light and porous, and by degrees produce 'a better soil; it will admit air, and tend mechanically to im-'prove the condition of the soil.' H. C. Committee 1863. 1157.

As to the Value per Ton in a Liquid State.

'Theoretical calculations have no practical bearing, because 'you arrive at a result which must necessarily be contradictory 'to practical experience. The intrinsic value of sewage manure 'is great, but the practical value is regulated by so many cir-'cumstances that it may be very different in two localities. 'Where the soil is light, and you can dispose of a large quan-'tity of grass cut green, the value of liquid manure will be great; 'in another locality you have no grass land, or where you 'would be obliged to make grass into hay (and there are prac-'tical difficulties in the way of doing it on grass land dressed 'with liquid manure), if you attempted to apply liquid manure 'its value would be much less, perhaps hardly worth the ex-'pense of applying it. The solid matter in a ton of liquid 'manure is worth (theoretically) 2*d*. a ton; but liquid manure 'itself is not worth nearly so much, because the solid matter 'is mixed up with such a large quantity of water.

Difference between the Application of Solid and Liquid Manure.

'In manuring with farm-yard dung or liquid manure, or 'with sheep-droppings, we put the manure where we like: we 'know from experience that it is of use; but in applying liquid 'manure we cannot apply it just in that portion of the soil 'where we want it. It goes through the whole of the soil, 'and *in order to produce an effect we must increase the quan-'tity to a large extent.*'

As to Quantity of Sewage required to give a Crop.

'You have in liquid manure a small quantity of solid mat'ters, amounting to seventy or eighty grains in a gallon, and a 'large quantity of water. By applying a limited quantity of 'the liquid, it penetrates a large body of the soil, incorporating 'a large body of soil with a small quantity of real fertilizing mat'ter; if we could extract that small quantity, and apply it as a 'top-dressing, so as to keep it entirely on the surface, we should 'manure that small portion of the soil, and it would there 'produce an effect upon the crop; but being all washed into 'the soil, it produces no effect unless we use a large quantity. 'And for this reason, I am a strong advocate, I must plainly 'confess, on theoretical grounds, for the application of large 'quantities of liquid manure. When we apply a large mass, 'say 7000 or 8000 tons to a soil which is naturally porous 'and deep, we incorporate with a large body of soil a consider'able quantity of solid, real fertilizing matter. By using such 'large doses upon grass crops grown on a poor soil, these solid 'manuring matters which are disseminated through a large 'body of soil by capillary attraction are brought within reach 'of the roots of the plant. The evaporation which takes place 'from the leaves of grass-crops is very considerable; the 'moisture from a considerable depth is drawn up, and with it 'all the solid matters dissolved in it. Then we see a marked 'effect upon vegetation, which will explain in practical ex'perience why quantities of 300 to 400 tons an acre, even 'applied to grass, lead to no practical result, whilst large 'quantities applied to the extent of 8000 or 9000 tons (and 'I am not sure that even larger quantities may not be used 'with advantage) produce a good result. That is a matter 'which is clearly determined by experiment. I have nowhere 'seen such small quantities as 300 to 400 tons an acre pro'duce any decided beneficial and remunerative effect.'

Professor John Way has a European reputation as an agricultural chemist; he has made discoveries which Dr. Liebig, after first contemning, has been obliged to adopt, to account for the failure of his mineral manure. Professor Way was employed by the first Board of Health, and his analyses first drew attention to the manurial value of liquid sewage. He was for many years consulting chemist to the Royal Agricultural Society, and has devoted several papers on the subject in the 'Journal of the Royal Agricultural Society,' well worth consulting by those who really wish to be informed on the subject of liquid manure. No man has been more anxious to extend the use of sewage, but he takes the view of a practical philosopher. Mr. Ellis quotes, or rather misquotes, Professor Way in support of his scheme of small doses applied to all land, including clay, at 2*d.* per ton.

As to the Theoretical Value of Sewage compared with Guano.

Professor Way, being asked as to a valuation of sewage at 2*d.* per ton, founded on his analysis, said:—

H. C. Committee 1861. 4832.

'These analyses have been continually used in discussion, 'in spite of the fact that I have over and over again repudiated them. These analyses were taken previous to 1850—'I cannot well tell in what year—under the authority of the 'Board of Health: at any rate, the officers of the Board of 'Health were employed in collecting the samples from two 'places which were not outfalls of sewers at all. They were 'dipped out of the man-hole in Dorset Square, and a place 'called Barrett's Court, near Oxford Street. At the time 'these were made no other analyses had ever been made, *and 'I regret now very much that I ever published them, because 'they have been used for advocating a view in which I do not 'at all coincide. I do not believe that the sewage of London 'is of anything like the value that has been calculated from 'them.* At the time they were published I made this remark 'at the end: "These calculations must be looked on as merely '"an expression of the great agricultural value of the sewer '"water of towns, not as an attempt to fix that value with any '"approximation even to the truth. I have a right to com-

'" plain that the analyses which were made by me fourteen '" years ago, and which I have repudiated, have been used '" as a basis of all these calculations."' Professor Way further stated that analyses taken from the Northumberland sewer in 1859 showed less than half the percentage of ammonia of that taken from Dorset Square; and he added, quoting from a pamphlet he published in 1854, 'the value of the ' London sewage would differ at every great outfall. No one ' sample from one sewer would give you a fair indication of ' what the whole of the London sewage would be; it was only ' when the sewage of London came to be collected together at ' one outfall that you have any chance of forming a knowledge ' of its value; and I go further than that, and say that *when ' you have the value of the ingredients analysed you have by ' no means arrived at the value of the sewage practically for ' farming operations*.' 'Judging from the analysis, I should ' think its value from the ingredients *(that is to say, apart ' from the question whether its ingredients are of the same value ' in liquid sewage, which I dispute altogether)* would be 1*d*. ' to 1½*d*. per ton. The sewage of Rugby is richer than the ' sewage of London, in having a less proportion of water,—that ' is to say, the water of London sewage bears to Rugby sewage ' the proportion of 100 to 66.'

How to apply Sewage.

'A system of sewage distribution must not be interpolated ' with ordinary farming, because under the ordinary system of ' farming you cannot and never could get rid of it all. That is ' to say, if you were to lay down pipes over a farm where I was ' farming in the ordinary way of shift and the ordinary way of ' rotation, there are times when I should altogether decline to ' receive the sewage, and you would not be able to get rid of ' it, because all the farmers in the same district would decline ' to receive the sewage at the same moment.* For these rea-

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* 'The agriculturist must be made aware that by the introduction of sewage his whole system of farming undergoes a change, and that he has to make an apprenticeship to apply it rightly and economically, and in order to benefit and not to injure his fields.'—*Liebig's Letter to Lord R. Montagu.*

'sons, the land over which the sewage of London is to be distributed must be laid out specially for the reception of sewage. 'With my present knowledge of the subject, *if I were a 'capitalist and had to deal with a quantity of sewage so as to 'use it to the best advantage, I should select a pure sandy soil 'in preference to anything approaching to clay, because I can 'make sand, by the application of sewage, richer in clay every 'year I applied sewage to it, apart from the fact that I could 'add clay if I wished, but I could never get a clay soil open 'enough to receive sewage.*

'I say that, on the one hand, in using large quantities of 'sewage, you undoubtedly carry away from the land a quantity of valuable matter; but my belief is that that is a necessity of the case. You cannot do otherwise; but if you ask 'me how I am to make, regardless of cost, the manurial ingredients of the sewage into the greatest amount of produce 'of any kind, then I would put it on with pipes and hose in 'small quantities, almost as I would in garden cultivation— 'as if I were watering it with watering-pots—but it would 'never pay to do it. With hose and jet you would never get 'the quantities on that it would pay you to put on.'

Again, in reference to the probability of retailing sewage to ordinary farmers on ordinary farms, the Professor says:—

'The farmer cannot take sewage at all times; if he is bound 'to take large quantities at all times, he would soon decline to 'take it at all. He could not do it in times of rain like June, 'July, or October (1862). It must be put on land expressly 'prepared for it, laid out expressly for irrigation with sewage.'

As to the quantity of land and quality of soil, Mr. Way says:—

'A dry absolute clay is the last soil I should wish to use 'sewage upon, because although it has the power of extracting 'the manurial qualities of the sewage, it is physically unfit for the purpose; the sewage cannot get into it. (It should be 'noted that the environs of London for many miles on the 'north side are composed of the stiffest kind of clay—London clay.) Even if the clay were ever so well drained, the 'liquid would run over it. You could advantageously use the 'sewage of 3,000,000 people on 30,000 acres; that would 'be the excreta of 100 people per acre, provided it was all 'grass-land; but it would be advantageous to take a larger 'area, because the only way in which you can deal with it 'is by feeding it into milk or into flesh, and you would 'have a very large quantity of manure produced by the cattle 'in addition to the sewage; consequently, you will have the 'means of returning an immense quantity of manure to the 'land.'

Mr. John Bennett Lawes, of Rothampstead, a Fellow of the Royal Society, a member of the Council of the Royal Agricultural Society, and by inheritance a Hertfordshire squire, was educated at Oxford; from his boyhood he had a taste for chemical studies, and has for thirty years been engaged in making and recording agricultural experiments. He was the first who availed himself of Professor Liebig's hint, and established in 1841–2 a manufacture of superphosphate of lime, from which he has for many years realized a large income. For twenty years he has expended more than £1000 a year in chemical experiments, on land, which have been regularly published in the pages of the Journal of the Royal Agricultural Society.* He has engaged, to direct these experiments, Dr. Gilbert, a chemist of undoubted reputation. Professor Way in his evidence (H. C. Committee, 1864, 4792) observes:—'There is one great peculiarity in Mr. Lawes's career: for many years he has expended a large sum of money annually in making agricultural experiments, which, although he has freely reported them to the public, have not been in favour of his trade as a manure merchant, but on the contrary, Mr. Lawes makes superphosphate of lime, and has found that superphosphate is of a very little use, except for root crops. If he had been seeking to promote his own interests, he had better have left these experiments alone.'

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* See 'Report of Experiments on the Growth of Wheat for Twenty Years in succession on the same Land.' By J. B. Lawes, F.R.S., F.C.S., and J. H. Gilbert, Ph.D., F.R.S.

Mr. Lawes is a member of the Royal Commission appointed in 1857 to investigate the value of sewage. The experiments of the Commission were entrusted to Mr. Lawes, 'because he had a properly hired staff of officers, and all the experience necessary for carrying on experiments in agriculture.'

Sewage on Arable Land.

Mr. Lawes says—

'If you are to apply sewage all the year round as it should 'be applied, it is inapplicable to all arable land; but if a person can apply it to-day and not apply it to-morrow, just as 'he pleases, he may apply it to all crops. The great difficulty of applying sewage to roots is that a greater part of 'the year you cannot put sewage on the land without damage 'to the crops.' H. C. Committee 1863. 369.

Profitableness of Sewage on Grass.

'An acre of grass unmanured, kept a cow twenty 'weeks, producing milk, the value of which, at 8*d*. per gallon, was	£11	3	0
'An acre of grass with 1500 tons of sewage, 'kept a cow forty weeks, producing milk worth .	18	14	0
'An acre with 3000 tons of sewage, kept a cow 'fifty-eight weeks, producing milk worth . . .	26	18	0
'An acre with 4604 tons of sewage, kept a cow 'sixty-eight weeks, producing milk worth . .	31	11	0

As to Value.

4524. 'I would give 2*d*. per ton for the sewage of London, delivered in such quantities and at such times as I required it,

‘but would not give a halfpenny a ton, to be obliged to take it
‘the whole year round, and be obliged to pay the expense of
‘subpiping and carriage through the farm.

598. ‘If at Rugby anything like 10,000 tons were put on the
‘land, I would value it at a rent of £25 an acre.

413. ‘The largest produce I ever obtained from an enormous
‘supply of dry manure, was about twelve tons of green produce.
‘Six thousand tons of sewage produced an increase from nine
‘tons of grass to twenty-two tons.’

Quantities of Sewage used.

H. C. Committee 1864. 4502. ‘The reason why the Commission use larger quantities of
‘sewage in preference to small ones, is because, having visited
‘all the towns where sewage was applied, they found that
‘those who had covered their lands with pipes had begun to
‘give up the use of these pipes, and concentrate the sewage.
‘On Mr. Walker’s farm at Rugby, 450 acres were piped; but
‘the tenants have abandoned the use of the greater part of
‘the pipes, and were beginning to use the sewage in a concen-
‘trated form, large quantities on a small area.

‘The Earl of Essex for the sewage of 4000 people laid
‘down pipes under 200 acres, but now puts all the sewage on
‘seven or eight acres of Italian rye-grass during the summer,
‘and on thirty or forty acres of his park during the winter.
‘Therefore the Commissioners did not think it worth while to
‘spend the money of the country in what had already been
‘found to be unprofitable.’

Best Application of Sewage.

4537. ‘To apply it to the most porous sandy land you can get,
4562. ‘like Bagshot Heath, because you have no natural produce
‘and no cost to begin with; whereas if you take heavy land, on
‘the banks of the Thames, your rent is something like four
‘pounds an acre to begin with; *in the other process you can*
‘*obtain a large profit from converting something almost worth-*
‘*less into something very valuable.*

In answer to a question from Mr. Bright, Mr. Lawes said :—

'From 30*s*. to 40*s*. a year per acre would pay for the ordi-
'nary application of guano to land; but it might pay a farmer
'to give £12 an acre for 6000 tons of town sewage at ½*d*. per
'ton, because it pays the Edinburgh one to give £30 or £40
'an acre for sewaged land, although a common farmer only
'pays £1 an acre; but the sewage farmer must change his
'mode of agriculture, and revolutionize his whole industry.
'The application of sewage is quite a special mode of farming, 4583.
'totally different from the ordinary farming of the country.'

Value of Sewage dependent on Climate.

'In 1862, the temperature was so low that the sewage was 4668.
'of little value; there was a large crop of grass, but it had
'very little milk-producing qualities.'

Mr. Robert Rawlinson, C.E., was one of the Inspecting Engineers under the first Board of Health, 1848, Sanitary Commissioner to the British Army in the Crimea, and a member of the Royal Sewage Commission, appointed in 1857. He formerly had a much higher idea of the value of sewage then he has at present;* but amongst the many towns sewered under his direction are Carlisle and Alnwick. At the first, sewage is profitably applied to grass-land by simple irrigation.

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* Mr. Rawlinson at one time held more extravagant ideas of the value of sewage manure, but has had the good sense to profit by experience, and the candour to avow his changed opinions. In his Report to the General Board of Health, May, 1851, on the sewering works resumed at Pendleton, he says that he has "*little doubt that the refuse of Pendleton may, in the first instance, be let at an annual sum equivalent to the whole rate*, £650 *per annum*, required to pay expenditure on the sanitary works within thirty years." And in a note he quotes an article from the 'Times' giving an account of Dover's solid manure process. Mr. Dover rates the value of the manure arising from the population of the United Kingdom at £52,000,000. He valued his British guano at £5 a ton!

At Alnwick, the farmers find the cost of working the pumping apparatus greater than the crops will bear. Mr. Rawlinson no longer advocates the elaborate and expensive system of applying sewage which was earnestly recommended by the first Board of Health.

ENGINEERS' EVIDENCE.

MR. RAWLINSON.

Value and Application.

H. C. ‘I am the part proprietor of a small estate at Worthing;
Committee 1864. ‘we are going to apply the sewage as it is applied at Croydon.
4105. ‘At Worthing they act with wisdom—they charge nothing for
‘the sewage. If they had charged anything, there would have
‘been no experiments; they give the sewage; they lift it on
‘the land. We are going to put the sewage of 2000 people
‘on 42 acres.

4132. ‘Edinburgh is a great agricultural success, because meadows
‘produce four or five crops of Italian rye-grass per annum,
‘and as much as 80 tons per Scotch acre of grass has been
‘taken. These meadows have let at an amount from £25 to
‘£40 per acre. But had there been anything like the value
‘I have heard put upon sewage to pay (2*d.* per ton), the value
‘would have been on the opposite side. I believe, if any com-
4133. ‘pany is induced to enter into the speculation of applying the
‘sewage of London, and agree to pay the sums I have heard
‘named, they will be in bankruptcy very shortly.

‘I do not approve of the method of passing sewage through
4140. ‘small pipes, and applying it by hose and jet. You cannot
4160. ‘make sewage pay in that way. Sewage is a constant quan-
‘tity; that is to say, the volume is variable, but the flow is
‘constant.

‘The cheapest method of using sewage is by gravitation, ‘where the conditions will allow; you may pump with advantage (under certain circumstances), but I would not subdistribute sewage by hose and jet.

'The sewage of the Metropolis would require, not a million, 4162.
'but about 30,000 acres for profitable distribution.'

How to treat London Sewage.

'If I had to do with the sewage of London, I should try to 'get it on an area of 30,000 acres. *If I tried to distribute it 'over four times that area, the cost would not be four times as 'great, but sixteen times as great, both for distributing it and 'managing it.*

MR. WILLIAM HAYWOOD, engineer to the City Commissioners of Sewers, speaking at the Society of Arts, in December, 1855, takes the same view as Mr. Rawlinson of the costliness of hose and jet, with the inevitable manual labour not required on the water-meadow system.

'The provision of the distributing apparatus, and the cost 'of distributing, was the principal item of charge in irrigating 'land by hose and jet. In the pamphlets of the Board of Health, 'which were not remarkable for giving estimates of a very high 'figure, the cost of this distributing apparatus was from '£1. 10*s*. to £2 per acre (about half the real cost), and the 'interest upon that had to be taken into account, and, above 'all, the current working expenses. Sewage on this system 'would not distribute itself, but required manual labour and 'a large supply of hose. The cost of hose would be found to 'be a large element in the cost of distribution. The wear 'and tear of hose was exceedingly great. Canvas hose was 'taken in Board of Health estimates, because it was the cheap'est. He had used every species of hose, and had no hesi'tation in saying that canvas hose was the worst; it wore 'out more quickly than any other.'

MR. JAMES FENTON is the engineer of the Local Board of Health, Croydon.

'I think open watercourses better than pipes, because the 2198.
'water is more easily regulated and at less expense: pipes 'are perpetually stopping up. You must have engine power

'and a head, or you can never drive it through pipes; pump-
'ing is a very serious expense.

2015. 'In the year 1860, which was a hot, dry summer, a field
'of oats, ten acres, a porous gravel, was not irrigated by the
'water running over the surface, but the water gathered
'through the under soil, cooling the earth, and applying the
'manure to the roots. The result was an increase from four
'or five quarters per acre to twelve quarters.'

AGRICULTURAL EVIDENCE.

MR. SAMUEL CHRISTIE MILLER, formerly a member of Parliament, is proprietor of the Craigintenny meadows, Edinburgh.

H. C. Committee 1864. 3058. '200 acres irrigated by gravitation, about 50 by steam power
'pumping. These meadows receive the sewage of about
'80,000 inhabitants of Edinburgh. The whole surface is di-
'vided into convenient patches for irrigation by surface works.
'The sewage flows constantly night and day. As far as prac-
'ticable, we continuously irrigate night and day.

3175. 'The application by steam-power has not been very profit-
'able. We should otherwise have not ploughed it up for arable
'purposes. About ten acres a year have been ploughed up
'[and sewage irrigation discontinued], and I think that has
3178. 'been the case pretty much throughout Scotland. I have
'seen a good deal of irrigation. We have greater advantages
'than most people, but there has been a good deal of money
'lost by pipe drainage and pumping.

3178. 'It is when seasons are warm that the greatest effect is pro-
'duced. It is marvellous to see the grass grow in hot weather,
'when it has been cut, and the roots are quite white from a
'heavy crop; [after a dressing of sewage] it will be quite
'green in forty-eight hours. We have applied sewage to arable
'land, but there is very great difficulty in applying sewage to
'arable land. I am satisfied that sewage is not likely to be
3228. 'beneficial to wheat; and I doubt whether turnips would be
'benefited by immediate application of sewage manure. I

‘ have seen sewage put upon young wheat, but it is very difficult;
‘ it might possibly be put on by hose and jet, but water
‘ upon arable land makes furrows and channels, and washes the
‘ roots of wheat bare; so it does with turnips.

‘ I believe sewage is far more suited to grass than any other
‘ crop. I doubt whether you could apply sewage to wheat
‘ crops by hose and jet at given periods with advantage. You
‘ might apply it to grass for a couple of years, and then plough
‘ up for wheat.

‘ I consider open gutters the best way of applying sewage;
‘ pipes are such a bother that they are comparatively useless.’

THE EARL OF ESSEX is Chairman of the Royal Commission for investigating the value of sewage.

‘ I began using the sewage of Watford about seven or eight 1.
‘ years ago, under the impression there would be sufficient to
‘ irrigate 210 acres, and underpiped that quantity of land. I
‘ get about 60,000 tons a year, averaging four working days to H. C.
‘ the week; and I calculate, with all my unnecessary outlay, Committee
‘ that it cost me 1*d.* to ¾*d.* a ton. I apply it to 10 acres of 1863. 32.
‘ Italian rye-grass, and to 35 acres of meadow-grass. I put
‘ about 5000 or 6000 tons a year to each acre of Italian rye-grass, 100.
‘ and 600 tons on each acre of 35 acres of meadow,
‘ making between 60,000 and 70,000 tons I calculate I get
‘ from the 4000 inhabitants of Watford.

‘ I think you ought to calculate for Italian rye-grass from 62.
‘ 5000 to 6000 tons a year per acre; if you have more, you can
‘ apply it to other crops.

‘ With regard to Italian rye-grass, to which, according to
‘ my experience, sewage is more suitable than anything else,
‘ during the whole summer on seven acres I have fattened
‘ thirteen bullocks, kept seven or eight horses or ponies, and
‘ an indefinite number of pigs.

‘ I transplanted nine acres of cabbage and rape late in the
‘ autumn under the influence of sewage, and I have now got
‘ on these nine acres most admirable food for lambs, which I

'could not have had without. It is the best crop I ever had 'by seven, or eight, or ten tons.

28. 'During a very hot summer, about four years ago, I had 'seven acres of mangel-wurzel, of which four-fifths were de'stroyed by fly. I transplanted it with sewage, the weather 'being intensely hot. There were just enough plants to cover 'seven acres, and the result was a crop of 47 tons per acre, en'tirely saved by the sewage.'

> MR. JAMES ARCHIBALD CAMPBELL is a gentleman of good family and fortune, who settled at Rugby several years ago to educate his sons at the celebrated school there, and also with the hope of renewing at Rugby the wonders obtained by the application of sewage manure at Edinburgh. He became, and is still, one of Mr. Walker's tenants; and it is a significant fact that, arriving in England an enthusiast on the subject of liquid sewage, he has been compelled to moderate his hopes in consequence of the excessive dilution of the sewage. Mr. Campbell has a large dairy-farm.

The following is an extract from a letter addressed by him to a daily paper:—

'I am no great artificial manure manufacturer, nor have I 'any pecuniary interest in that article any more than I have 'in any scheme for utilizing the London sewage; but for nine 'years I have been using town sewage as an agriculturist, and 'hope to see the time when none of it will be wasted. It is 'because I think highly of sewage as a fertilizer, and am san'guine about its future employment, that I deprecate exagge'rated statements as to its value to the farmer. To me, as to 'a practical man, the statements of Mr. Ellis are so extreme as 'to be positively ludicrous. Long before the Royal Sewage 'Commission experiments were commenced at Rugby, I used 'the sewage in large and in small quantities, on grass land 'and on arable land, and I am still using it, independent of 'such experiments.

‘Mr. Ellis puts the value of sewage at 2*d.* per ton on the faith of certain analyses made by Messrs. Hofmann and Witt. Dr. Gilbert says, and I have reason to believe correctly, that these analyses were made from sewage kept as free as possible from rainfall, and therefore to that extent the estimate is too high. Baron Liebig, in a letter published by Mr. Alderman Mechi in the “Agricultural Gazette” of 22nd August last, estimates the value at 4*d.* per ton, if a certain amount of phosphates be added, otherwise at 1⅓*d.* per ton. When doctors differ, who is to decide? I maintain, as a practical man and no doctor, that these estimates are theoretical and fallacious. Let it be granted, for the sake of argument, that the quality and value of the manurial constituents of sewage are correctly stated as equal to 2*d.* in the ton, it does not therefore follow that that ton of sewage is worth 2*d.* to the farmer —far from it, notwithstanding Mr. Ellis's assertion that the liquid increases the value. I have no hesitation in saying that the very reverse is the fact; that the bulk of the liquid is a very serious drawback, save under very exceptional conditions. Now, if it be not worth 2*d.* per ton to the farmer, it is worth still less to the ratepayers, or shareholders, or proprietors of any kind, because it is only at certain seasons and particular periods of the growth of crops that the farmer will take it. But the sewage must be utilized or got rid of all the year round, irrespective of atmospheric conditions; and who is to take it or pay for it? Not the farmer assuredly, or certainly not at the same rate of payment, for the value of liquid manure in the winter months, when the soil is saturated with rain and vegetation torpid, must be very much less than in the summer, when evaporation is great and vegetation luxuriant.’

Again, Mr. Campbell at the Central Farmers' Club said:—

‘When he commenced [eight years previously] using sewage near Rugby, it was with a very strong idea of its great value. He was well acquainted with the sewage meadows of Edinburgh, having been in the habit of spending his winters in that

‘ city, and had seen the enormous crops obtained from sewage.
‘ Accordingly, when he went to reside at Rugby, he was glad to
‘ enter into arrangements [with Mr. Walker] for securing him
‘ the benefit of sewage. He was to have five dressings applied
‘ to his land, extending from the month of March to the month
‘ of October, for the sum of £1. 1*s.* per acre. At the outset a
‘ question arose as to what constituted a dressing. It was left
‘ to Alderman Mechi to say how much it was to be, and he de-
‘ cided that the quantity was 9000 gallons, so that his five
‘ dressings in the year amounted to 45,000. He soon found,
‘ however, that the quantity did not do. Applying the sewage
‘ by hose and jet in small amounts he saw no appreciable effect,
‘ and he began in the very first season to concentrate the ma-
‘ nure. Every year he had been concentrating liquid manure on
‘ a smaller space, until at last the whole of the manure for which
‘ he paid £150 per annum was actually upon about twelve
acres of land.’

> SIR JOSEPH PAXTON, M.P., is too well known to require introduction. He was actively interested in farming as agent to the Duke of Devonshire. The experiments he mentions were tried at the request of Mr. Chadwick, but did not bear out that gentleman's theories.

2463. ‘ I consider this sewage is a great rough sort of business;
‘ you cannot put it into nice forms and ways. You must be
‘ satisfied with securing a large amount of good out of it, and
‘ not attempt or think you can bring it into such a form that
2444. ‘ it can be applicable by everybody. The application of sewage
‘ in the extended form in which it has been suggested, will be
‘ the greatest difficulty when you come to the farmers. They
‘ will have their own way; I have no notion of forcing a man
‘ to do that which he does not believe he ought to do. I say
‘ that to apply sewage to some 300,000 or 400,000 acres would
‘ be a dead failure, as far as commercial success goes.

2425. ‘ *A sandy soil is the best, according to my judgment, from*
‘ *my application of it; a soil which will allow a very large*
‘ *quantity to pass through it without artificial drainage;*

'where there is artificial drainage, sometimes the liquid 'manure, by the drains not being closely filled up, or not full, 'gets away into the pipes and is taken away in the drainage; 'but where you have it in sand, or nearly all sand, a very 'strong sandy land, you have the very best drainage for the 'application of sewage manure. I had a tank close to my 'residence; I put it there some fourteen years ago, with a 'view of testing sewage upon various kinds of lands, and I 'found that, rateably, I could place the sewage made by '250 persons over an acre of land in a year, and that with 'very great results as to the growth of plants.

'The water with which this liquid manure was diluted, was 'not more than one-tenth of the amount in London sewage. 2451.

'*On sand, in proper weather, you can hardly apply too* 2427. '*much sewage to vegetation*; in clay land, of course, it is 'otherwise, because it cannot pass off. Plants do not develop 'matter for the food of man or animals to any great ex'tent unless there is a corresponding amount of light and heat. 'The first effort of a plant, after the seed is sown, is growth, 'and then it has a strong development; and then its ultimate 'object is to reproduce itself; and it is at the time when it 'is going into that state of reproduction, or approaching to 'that condition where it becomes very similar to reproduc'tion, that it contains the greatest amount of nourishment. 'Therefore, the application of all sewage will be most beneficial 'in the spring of the year and early in the spring; you will 'then have also the warmth of the sewage, which will be a 'very great advantage to the soil.

'Being asked by the Chairman, Would you not consider 'small dressings of land (by hose and jet) by sewage, just 'sufficient to wet the roots of plants, a better plan than to 'apply a larger quantity?—*I should like it very much, if* '*you can show me how to do it; but I have not the slightest* '*notion that you will ever get that system applied to an ex*'*tent which would be necessary for the using of the London* '*sewage.* According to the calculation which I have given 'you, namely, that the excrement of 250 persons can be 'used upon an acre of ground, it would take something 'like 30,000 acres of land to extract all the absolute growth 'that is necessary, out of the sewage of the Metropolis. 'Now, as London contains 3,000,000 persons, and as you 'have, passing over Teddington Lock every day, taken 'up by the water companies something like 90,000,000 gal'lons of water, and you have a rainfall of about 30,000,000 gal'lons more, taking it at a rough guess, and without going into 'all the minutiæ of it, you have something like forty gallons 'per person every day. I need not tell you that forty gal'lons would not be very strongly impregnated with matter 'which would highly develope plants. On the other hand, I 'I believe that water alone, if you could get water delivered 'to the land at certain times when you want it (in April and 'May if rain be wanting, and in August and September to 'mangolds), would be worth 1½*d.* or 2*d.* a ton.'

MR. SAMUEL BURY CONGREVE is a tenant farmer and grazier, who first managed one of the sewage farms at Rugby for Mr. Walker, the proprietor, and afterwards rented it.

'Rugby has an average supply of 97,000 gallons daily, the 'maximum being 190,000 gallons, and the minimum 35,000 'gallons. The sewage of Rugby, 8000 inhabitants, can be 'applied to 400 acres [practically the area of application has 'been very much reduced]. I never found the sewage strong;
5042. 'the great difficulty has been that it is too dilute: the great 'difficulty has been to get rid of the water.

'If I had a farm in the neighbourhood of London, I would
5057. 'take sewage if I were at liberty to take it when it suited my
5058. 'purpose; I should apply it over a very limited area at a cer'tain time of the year. If I were compelled to take it at all 'times, I should refuse it altogether.

'Sewage will greatly increase grass crops, natural and arti-
5063. 'ficial, on poor land. You cannot apply it with good effect
5065. 'to roots, because it contains so much water that your land 'is in a state of sea if you get any quantity into it. It will 'increase the quantity of straw, but not of corn.'

CHAPTER IV.

CONCLUSIONS FROM EVIDENCE IN CHAPTER III., AND THE CONTRARY SIDE STATED.

IN the preceding Chapter, the evidence of "competent" witnesses,—agricultural chemists, engineers, and agriculturists,—has established the following conclusions:—

1. That the liquid sewage of a great city may be made to produce a considerable profit if it be applied by gravitation in a suitable manner on a suitable soil.

2. That the most suitable soil is a sandy, porous soil; and the more barren, the more profitable will be the application.

3. That where it is essential to dispose daily of a constant flow of sewage (too great to be stored for occasional use), grasses, natural or artificial, are the more profitable crops.

4. That the most economical and profitable application is by gravitation by open channel irrigation on the water-meadow system, so as to cover each meadow at suitable periods with a thin film of liquid, and pass the sewage from field to field until the utmost amount of manurial value has been exhausted.

5. That a supply of sewage would be of great value to the ordinary crops of an arable farm, such as cereals,

roots, beans, etc., as well as grass intended for hay *in times of drought*; and that such *occasional sewage service*, delivered by gravitation, would be worth a very much higher rent, either per ton or per acre, than a constant service.

6. That liquid sewage cannot with advantage be constantly applied to clay soils in substitution for farm long-straw manure, because long-straw manure has a beneficial mechanical effect in loosening clay, which liquid in any quantity consolidates.

7. That arable farms (except as regards artificial grasses) cannot be employed to receive the bulk of a *constant supply* of sewage, because the most important crops of an arable farm would, during many months of the year, be damaged by either excessive rain or artificial irrigation. That it is essential, in order to obtain the utmost profit from a constant supply of liquid sewage, that farms irrigated should be specially laid out as "sewage manure farms." A constant daily supply cannot be made to dovetail with the ordinary rotations of an arable farm.

In the preceding pages the expression "competent" witnesses has been used more than once. By "competent" is meant persons who, by special education, special study, or lengthened experience, can speak with some authority on the subject under consideration. Assurance and volubility do not make valuable the evidence of a person who only relates what he read in a book, or heard from a person with no more authority than himself.

Many pages of the H. C. Reports are filled up with the evidence of persons whose experience has been confined to small experiments with the liquid manure of a farm or a house. One witness finally admitted that the liquid manure of 700 persons was distributed over half an acre at a time with a steam-engine at a cost 10s. 6d. per day—a fact from no view of which coul ne Committee derive any useful knowledge.

In dealing with the question of town sewage, it must not be confounded with more condensed liquid manure, which is quite a different thing. Sir Joseph Paxton put the sewage of 250 persons on one acre of porous soil with excellent effect; but this, he tells us, did not contain one-tenth the water which dilutes London sewage; that is, the *excreta* of each person were diluted with less than four gallons, instead of forty gallons. Mr. Bury Congreve, the tenant farmer of Rugby, complained that the sewage, even in the summer season, when the lowest water-supply occurred, was always 'too dilute;' and Professor Way states that the dilution of London is to Rugby as 100 to 66. Mr. Miller, the owner of the Edinburgh meadow, says his tenants sometimes complain that they have too little sewage, never too much. Water—invaluable in tropical climates, very valuable in Spain and Italy—is a cause of great embarrassment and expense in a country where there are harvests often damaged by too much rain, rarely by drought.

For this and other reasons we do not consider that the evidence of Mr. Philip S. Miles, or the guesses of Mr. Westwood, throw any light on the daily utilization of such an enormous bulk of such a diluted article as London sewage.

Mr. Philip Skinner Miles, formerly M.P. for Bristol, and a man of great wealth, has a country house at King's Weston, at the top of a hill, which is on an average occupied by thirty persons, all of whom use water-closets. The sewage from this house is conveyed by a pipe to a reservoir, which, on an average, is filled every week; in times of rain it fills in four or five days. The contents of this reservoir are, when full, distributed over twelve acres of grass-land by gravitation, by pipe and hose from underground pipes, without any expense for pumping, by an old man, being the best and cheapest application of house sewage that has been reported. The result is 'a good cut of grass in the spring, a ton and a half of hay, and after the hay is cut a feed of grass that carries Mr. Miles's stock on until November.' Mr. Miles *thinks* that this application has doubled the value of the land. He says, with great candour, 'I have never done anything regular with the view of keeping accounts or testing the matter at all, and that is why I was rather loath to be examined, because I knew I could not give accounts, and no opinions are valuable unless they are accurate.'

Mr. Miles's evidence is valuable as an example for country gentlemen, who have a mansion on a hill, but, as a guide to the value of town sewage, it is utterly worthless. The sewage of King's Weston House is only diluted by 'the runnings of the house, washhouse, and overflow of cistern,'—except in time of rain, certainly not one-tenth of the water-supply of any town. It is not the sort of weak stuff of which Mr. Congreve complained, but 'strong liquid manure' well applied. As to the doubled value of the land, it may be true, but it is evidently a mere guess. Squires naturally take a favourable view of their agricultural experiments, and the squire's bailiff naturally likes to flatter the squire.

Mr. William Westwood had been a farmer. From 1851 to 1857 he was bailiff of the Pauper Schools at Anerly. There were 700 persons in the school. The land is a strong London clay, cultivated by the spade and fork labour of the pauper boys. The land was dressed with sewage, viz. four acres of Italian rye-grass, and twelve acres of meadow grass. The produce of the four acres, dressed with what he estimate at fifteen hundred tons per acre, fed sixteen dairy cows, one bull, three or four young stock, and three farm horses, each for 180 days. The twelve acres of very poor meadow-grass irrigated on the catch-water system, over which the sewage flowed winter and summer, to an amount estimated by Mr. Westwood at eight or nine thousand tons per acre per annum. The result was only $2\frac{1}{2}$ tons of hay per annum. Here, he says justly, most of the sewage was wasted, as the bulk passed over and through the cracks in the land almost without change.

Mr. Westwood is of opinion that the only effect of these thousands of tons of sewage was to raise the produce of hay from $\frac{3}{4}$ of a ton to $2\frac{1}{2}$ tons in two crops. The four acres of Italian rye-grass were well cultivated by the spade-and-fork labour of the boys,—a mode of cultivation peculiarly suitable to clay soils, but very expensive.

This loose evidence has been quoted to show that increase of quantity of sewage produces no effect on crops, in contradiction of the exact experiments of Mr. Lawes. The explanation of the small return on the grass land at Norwood is plain. It is a stiff clay soil, laid up in high-backed lands. The effect of the constant flow of sewage was just what all the 'competent witnesses' we have quoted anticipated. It converted the soil into a compact mortar-like mass, and of course flowed over it. Had the soil been porous and self-drained, as at Rugby, or Watford, or Croydon, or Edinburgh, there would have been some sense in the comparison. The Norwood schools are a good example for the imitation pauper schools, where hand labour is cheap, and strong liquid manure plentiful. According to Mr. Chadwick's calculations, the inhabitants of the Norwood school could not have used more than 12½ gallons of water per head, exclusive of rain-water. Mr. Westwood's calculations, based on studies of Blue Books quite out of date, are worthless.

It was on the evidence of Mr. P. S. Miles and Mr. Westwood, backed by the very off-hand statements of Mr. Alderman Mechi, that the Committee of the Corporation of London, passing over the directly contrary opinions of the agricultural chemists, Professors Voelcker, Way, and Mr. J. B. Lawes,—the Engineers of the Board of Health, Mr. Robert Rawlinson, and the Agriculturists, Mr. Miller, Sir Joseph Paxton, Mr. J. C. Morton, and Mr. Congreve,—reported in favour of a scheme for retailing the sewage of the Metropolis over an area of half a million of acres, chiefly composed of strong clay, at a cost of five or six millions for engineering works, and an annual expense of over three hundred thousand pounds, in addition to a capital of at least three millions to be found by the farmers for distributing the sewage by pipe and hose.

Mr. Alderman Mechi may be called the *sensational* farmer of the age. What Miss Braddon is amongst novelists, Mr. Mechi is amongst gentlemen farmers. His farm is not much above 170 acres, or as large as two fields in West Norfolk or any other first-class farming district, and neither in quality of stock, success in crops, nor general style and neatness of cultivation, has he ever equalled the great farmers, whom, after a course of unsuccessful experiments, he has been obliged to imitate. As to his profits, when they are made out, the accountant will probably be obliged to omit all notice of the capital sunk in mistakes. But Alderman Mechi has a well-deserved reputation as a speaker and a writer. Although it may safely be said of his agricultural discourses, that "what is new is not true, what is true is not new," he has a pointed, witty, axiomatic style, a way of putting well-known agricultural truths in a new and striking light, which, had he, like Arthur Young, confined himself to writing, and left farming alone, would have ensured him a very high literary reputation. He is also one of the most amiable, hearty, hospitable, genial of men, well read in books and human nature—an acquisition in any society; but, from his sanguine and imaginative character, he is the most untrustworthy of witnesses on the profit-and-loss part of an agricultural question.

It is popularly believed that Mr. Alderman Mechi cultivates his farm with liquid manure. For several years at the Society of Arts and at the Central Farmers' Club, the Alderman expatiated on the superior value of liquid over solid manure, and stated that his live-stock—cattle, sheep, and pigs—were fed on open wooden floors, in order that their dung, unmixed with straw, might pass easily into the liquid-manure tank, and thence to be distributed by his steam-engine over his farm. But at some unknown period Mr. Mechi discovered that his clay-land farmer friends were not the fools he had taken them for, when they laughed at his liquid manure theory, and told him that he would have to come back to solid long straw. One evening, at a discussion at the Central Farmers' Club, on the cultivation of mangel-wurzel, the Alderman let the cat out of the bag, and related how he, too, had grown an extraordinary crop on his stiff-clay land by ploughing in fourteen or fifteen cartloads of long-straw nure, and stimulating his young mangel with a dose “Lawes's superphosphate.”

It is well known to Mr. Mechi's neighbours that the costly liquid-manure apparatus at Tiptree does not in any degree supersede the necessity for manufacturing farm-yard and purchasing portable manures. Its use is confined to dry seasons, and a very small area in such seasons; whether applied to cabbages or to mown grass, it produces a brilliant effect. But no man who knows anything of the expenses inevitable in a farm, would recommend an outlay of £6 or £8 an acre in order to secure a supply of artificial rain in a country which has on an average 150 days' rain in the year.

Closely examined, Alderman Mechi's evidence shows (although he puts a very high theoretical value on sewage) that he has no desire for a constant supply. He wants what every farmer would be glad to have and pay for when wanted,—an artificial rainfall, delivered by gravitation, without the expenses of a steam-engine and tanks, but he is now very careful not to assert that sewage would displace solid manure.

3338. Although Alderman Mechi has piped 170 acres, he
3352. 3352. applies it “principally to fifteen acres of grass, sometimes
to clover, and sometimes to cabbages.”

The Alderman attaches great value to water alone:—

> ‘In summer weather, when we have cut a heavy crop of grass,
> ‘when I have an insufficient quantity of our own sewage, I
> ‘sow three hundredweight of guano per acre, and charge
> ‘myself with 2*d*. a ton to put on 100 tons of water to wash
> ‘in the guano.
>
> ‘If it suits me, at *certain seasons* during the summer,
> ‘when there is growth to pay 2*d*. a ton per acre for water to
> ‘wash in guano, it would answer to pay 2*d*. to 3*d*. per ton for
> ‘sewage.’

And this is as far as Alderman Mechi ventured to go. At certain seasons farmers are to pay for sewage. He explained still more clearly, in a paper he read at the Central Farmers' Club, on the 5th of December last, that what he proposed in the distribution of sewage was not a constant daily supply, but a tap to which the farmer might resort when his land was thirsty.

It is scarcely necessary to observe, that a set of customers spread over half a million acres, who, instead of exclusively using liquid sewage for manure, only called for it in dry weather, would, even if they paid 4*d*. a ton, ruin any sewage manure company bound to take the daily flow of the metropolis, because such farmers would all refuse it for at least half the year, and have it all at the same season.

These are the Alderman's words:*—

'Those who, like myself, remember the time when there was 'no gas, and now see that in almost every house in the metropolis a supply of light is obtained by turning a tap, can 'easily foresee the time when each farmer *will turn on the tap* 'and supply himself with *town sewage through his meter according to his requirements.*'

In reply to Alderman Mechi, Dr. Voelcker said—

'They had been told the time would probably come when 'the farmer would merely have to open the sewage tap, just 'as the tap was now opened to let the gas out. But there was 'this important difference between gas and sewage, that if they 'opened the gas tap they got a splendid light at a cheaper 'rate than oil, wax, or candles of any description could be 'supplied, whereas, if the sewage tap were opened, it was very 'questionable what profit there would be. They might, indeed, 'get a very large profit, but, on the other hand, there might 'not be enough to pay for the outlay on the pipes. Now, that

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* Central Farmers' Club discussion, December 5, 1864.

‘ was a question which could not be settled in a general way; ‘ it was a question which depended especially on the character ‘ of the land. Whatever might be said about the wildness of ‘ the scheme of sending the metropolitan sewage down to ‘ Maplin Sands, at least this might be affirmed, that the land ‘ there was just the kind of land that was most likely to be ‘ benefited by sewage; for just in proportion as land was poor ‘ and hardly capable of producing anything, was sewage likely ‘ to be good, and just in proportion as land was naturally ‘ fertile was sewage unlikely to prove beneficial. He would ‘ be a very hazardous farmer who, having good pasture-land, ‘ poured upon it a large quantity of sewage manure, thereby ‘ converting it into that sort of rye-grass land of which Alderman ‘ man Mechi had spoken. He (Dr. Voelcker) would not deny ‘ the utility of sewage rye-grass for the keeping of stock in ‘ good condition; but he maintained that pasture grass was ‘ better. The more rapidly you forced produce of any kind, ‘ the less nutritive it became, bulk for bulk; the slower it ‘ grew, the more nutritive it was. On pasture-lands that was ‘ especially the case. By applying sewage to the land, they ‘ gradually reduced the herbage to one or two predominant ‘ grasses, favouring the growth of the coarser kinds, to the ‘ destruction of the finer; one particular grass—a coarse one— ‘ often prevailed. They all knew that in mixed herbage they ‘ had a variety of grasses, and that, bulk for bulk, those mixed ‘ grasses were more nutritive than the succulent produce which ‘ consisted of one particular kind of grass. He believed that ‘ if they had poor sandy land in the neighbourhood of large ‘ towns, where they could grow a large bulk of rank but still ‘ very useful fodder for milk-cows[*] or for the use of butchers,

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[*] In the same discussion, Mr. JAMES HOWARD, of Bedford, who occupies and owns a large steam-cultivated farm, said, ‘ He had lately ‘ visited Edinburgh, where meadows irrigated with sewage had been in ‘ existence for a hundred years; and so far from Baron Liebig's theory ‘ being true that town sewage did not contain the elements of permanent ‘ nent fertility, he (Mr. Howard) had found that the rental of those ‘ meadows had been constantly rising. When he visited Edinburgh, ‘ in 1855, the average rental was not more than £30 per acre; when he

'that would be a fit case for the application of sewage; but he 'was confident that in the midland counties generally it could 'not be used in the way that had been supposed with advan-'tage.'

The fact is, that Alderman Mechi finds himself in a dilemma between his wants as a farmer and his allegiance to his old friend Mr. Chadwick. He knows now what he did not know ten years ago, when he was one of the quoted examples of the original author of the 2*d.* a ton theory, that under no circumstances will liquid manure supersede farmyard on retentive soils; so he compromises with his conscience by declaring that he will be happy to take a supply of sewage at 2*d.* or 3*d.* per ton '*at certain seasons*.' When Mr. Chadwick first fixed on 2*d.* a ton as the value of sewage manure, he made estimates which, if correct, would have perfectly supported this valuation. He maintained that the water consumption of the metropolis ought not to amount to more than 12½ gallons per day. 'If,' said Mr. Lawes, in his speech at the Society of Arts, 19th March, 1855,—

> 'Mr. Chadwick would engage to supply farmers with liquid 'sewage at 2½*d.* per ton, in 12½ gallons of which there 'should be, beside extraneous matters, the daily excrement 'of one individual, he would not want customers, for in this 'way the farmer would get on his land the annual excrement 'of one person (not over-diluted) for the sum of 4*s.* 2*d.*'

'visited it last month, the average was over £35. It was a startling 'fact, that in nine years the rental of the sewage grass land near Edin-'burgh rose £5 per imperial acre; and this on land not worth 5*s.* per 'acre before sewage was applied.'

CHAPTER V.

THE PLAN SELECTED BY THE METROPOLITAN BOARD. AND WHY.

Eight towns have arrangements for using their sewage as manure,—Alnwick, Carlisle, Croydon, Edinburgh, Malvern, Rugby, Tavistock, and Watford. At Alnwick, the machinery for pumping the sewage on the land was erected by the Duke of Northumberland, but the farmers decline to pay the cost of pumping (see Appendix A). At Edinburgh, the large profits derived from the sewage of the city go to the landowner; at Tavistock, the landlord, the Duke of Bedford, presents the benefits of irrigation to his tenants; at Rugby £50 a year, at Watford £10 a year, is all the benefit to be derived, or likely apparently to be derived by the towns from the contents of the sewers. At Croydon and Carlisle, the present rent is a small profit on land leased for the purpose, but the future prospects of both towns are considerable, and so they seem at Malvern, where at present no rent is paid. At all the towns where sewage is most effectively and profitably employed, it is applied by gravitation and on the water-meadow system, the hose jet having been tried and discarded (see Appendix A).

The Metropolitan Board, obliged, after years of deliberation, to come to a conclusion, had these examples before them, and also the evidence of the very competent witnesses, which we have condensed and quoted, with much more to the same effect. For instance, Mr. Cuthbert Johnson, Fellow of the Royal Society, twice Chairman of the Board of Health of Croydon, has always been opposed to the use of the hose and jet in applying sewage to grass. He has for many years advocated its employment in meadow irrigation by gravitation. He never dreamt of superseding solid manure for either the cereal or root crops by liquid sewage. It was at his suggestion that the very valuable sewage-irrigated meads of Croydon were formed, and on to these all the sewage of the town has been for some years conveyed by gravitation, at the annual rate of from four to five thousand tons per acre; and this over about 250 acres of land.

Many projects were laid before the Board, but there was only one digested plan ready to be presented to Parliament, and promoted by parties of well-known authority and influence in the financial world. It was a question whether for an uncertain number of years the Board would allow the Thames to be polluted at Barking, while waiting for some plan infinitely more profitable than any known application of town sewage, or whether they would accept a plan supported by the evidence of the most practical and scientific witnesses, a plan which made the total removal of the nuisance of Thames pollution certain, and afforded a fair prospect of a large and annually increasing income,—an increase dependent, first, on the reclamation of and application of sewage to sands resembling in character the Edinburgh Craigintenny meadows, and, next, on the extent to which a demand for the continual or occasional use of sewage should arise in a district traversed by a sewage aqueduct forty miles in length.

Under these circumstances, after three years' deliberation and many discussions, after personally visiting the principal town-sewage farms, the Metropolitan Board by a large majority decided in favour of the plan promoted by Messrs Napier and Hope, the engineering features of which were prepared and supported in evidence by Mr. G. W. Hemans, C.E., M.R.I.A., &c. &c.

Mr. George Willoughby Hemans, C.E., is one of the Council of the Institution of Civil Engineers, and well known as having planned and executed first-class engineering works in Ireland, in this country and on the Continent, on which several millions of money have been expended. The following is an outline of the scheme which will be submitted by Messrs. Napier and Hope to the consideration of the present Parliament, of which a sketch is appended :—

A culvert will be constructed ten feet in diameter, which will tap the Northern Main Outfall Sewer of the Metropolitan Board at Abbey Mills, three miles from London. This culvert will run for a distance of three-and-a-half miles, with a fall of two feet per mile, to a point where the levels of the ground will require it to be lifted twenty feet. The discharge will then continue in a culvert of the same dimensions, sometimes in cutting, sometimes on embankment, until it reaches the head of the navigation of the river Crouch, at Battle's Bridge, in Essex, twenty-eight miles from the commencement at Abbey Mills. The sewage will be again lifted twelve feet by pumping at nine-and-a-half miles. The object of these lifts is, besides increasing the velocity of the current, to cause the culvert to command as much as possible of the surrounding country by gravitation. At Battle's Bridge the main culvert will divide into two smaller ones, running on the north and south sides of the river Crouch. That on the north will be eighteen miles long, terminating on the Dengie Flats; that on the south will be sixteen-and-a-quarter miles long, terminating on the Maplin Sands. Both these places are extensive foreshores on the east coast of Essex, dry at low water, and several miles in width, by about twenty miles of aggregate length. These vast plains are to be reclaimed from the sea by embankments (similar to those which are common in Lincolnshire, Holland, and other countries) to the extent of some eight thousand acres in the first instance; ultimately probably twenty thousand acres will be enclosed. There is scarcely any population at present along these dreary shores, which, however, will become, if the project is carried out, the most highly-fertilized lands in Great Britain. The sewage will be discharged upon these flats, and made to cover the whole of them by gravitation. The effect of this discharge when these sands are shut off from the sea by the banks, and other arrangements which will presently be described, will be to convert the barren surface into a tract on which crops of grass as rich as those on Craigintenny meadows may be grown. In the course of time, the gradual deposit of the particles held in suspense by the sewage will permanently increase the value of the sands.

As the distribution will be effected by gravitation, hand labour will only be required to keep the water-meadow channels clean and in order, at a trifling expense, once or twice a year.

From the nature of the sands there is no doubt that, if needful, all the sewage of the north side of the metropolis, at present 1,800,000, but say 2,000,000 of people, and 100,000,000 tons per annum, or 10,000,000 cubic feet daily, could be absorbed upon them; and therefore there is not the slightest hazard that when once the culvert to Maplin Sands is constructed, the Metropolitan Board will ever again be troubled by the pollution of the Thames.

But it is not the intention, and it will not be the interest of the contractors for the sewage to pour the whole mass on the sands; one-third of the length of the culvert will be high enough above ground to deliver a supply of the liquid, by gravitation, to the farms on either side. Arrangements will be made by reservoirs, or otherwise, for furnishing the two classes of farmers who may be likely to require either a constant or an occasional supply of sewage either to those who consider it will pay them to lay out their farms as sewage farms, and take a daily certain quantity; *or to the more numerous class who may desire to take a limited quantity of liquid in times of drought, or to start a hay crop after a first cutting, or for transplantation of cabbage or mangold, or other market garden purposes; in fact, to supply the desideratum mentioned by Alderman Mechi, of liquid sewage at 2d. or 3d. a ton,* ‘in *certain seasons*.’ The area which can be reached by gravitation from the culvert will exceed 80,000 acres; but if sewage be anything like the value which some persons believe, it will be easy, by short lifts and by pumping, to extend the area of utilization enormously.

The water drill is a most valuable expedient for securing a root crop in dry seasons; it can never be applied at a less expense than 6*s.* per acre. Now a supply of sewage by gravitation, although it might not altogether supersede the necessity of the superphosphate sown by the root drill, will enable farmers on the line of the culvert to water their seeds and artificial manures much more bountifully than the drill, and at about the same cost. *Thus, in dry seasons, the farms adjacent to the culvert will be supplied with such manure-rain as they require to stimulate seeds sown, or save a growing or transplanted crop;* while in rainy seasons the Maplin Sands would be available to absorb any quantity of the sewage of London; and this would not be waste, for the example of Edinburgh proves that large dressings produce large crops. There is no reason to doubt that the sands, now not worth 1*s.* an acre, can be converted into grass fields worth a rent of £30 an acre.

What better investment can be desired?

The capital required for executing the work of reclamation, constructing the culvert, and all the needful provisions for distributing the daily sewage of the north side of the metropolis, both on the sands and along the course of the culvert, has been estimated by the engineers, Mr. G. W. Hemans and Mr. J. F. Bateman, C.E., F.R.S., the eminent hydraulic engineer, at £2,100,000. The rents to be anticipated from the use of the sewage along the line of the culvert, and upon the reclaimed lands, have been calculated upon moderate data to yield a return which, though not amounting to £2,500,000 per annum, as boldly asserted by some persons, will still render the undertaking one of the most profitable speculations ever offered to the public, and in which the ratepayers of the metropolis will largely participate.

When the increasing, never-ceasing demands of the metropolis for milk are considered, there can be no doubt that this plan, which is certain to relieve London and the Thames of a formidable nuisance, will yield a large revenue, to be divided between the Metropolitan Board and the shareholders who will find the capital,—a revenue which will increase in proportion as the 'seasonable' demand for sewage along the line increases, and as the fertility of the Maplin Sands is developed.

CHAPTER VI.

THE THEORIES OF MR. THOMAS ELLIS.

ANOTHER project, or rather idea, for it has never assumed a tangible shape either in an engineering or a financial point of view,—a project based upon entirely opposite principles to the matured plan of Messrs. Napier and Hope, has been brought before the Metropolitan Board and the public by Mr. Thomas Ellis, in an unceasing torrent of pamphlets and newspaper correspondence. This project owes its importance to the advocacy of Dr. Brady, M.P.,* who supported it with all his influence in the two Committees of the House of Commons, and to its virtual adoption by the Common Council of the City of London in a report of the Council and Committee.

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* Dr. Brady has lately, in happy forgetfulness of the Parliamentary Reports of 1863, protested against being termed a *partisan* of Mr. Ellis and his 2*d*. a ton theory. On the 17th of April, 1863, Dr. Brady, in the House of Commons, attacked the Royal Commission on Sewage; talked of the 'all-powerful manure monopoly,' asked why the Commission had placed themselves in the hands of 'a large manufacturer of manure,' etc. The late Mr. Ker Seymer, than whom no man was more respected in the House, in reply said:—'The object of the Chairman (Dr. Brady) always appeared to be to find witnesses who would say that sewage was worth 2*d*. a ton, but he could not get them to say that.' Mr. Seymer also said, 'Mr. Lawes had discovered valuable manures and dealt in them, but he was also an English gentleman, and incapable of being actuated by the motives which had been attributed to him by the Chairman of the Committee' (Dr. Brady). Dr. Brady explained, 'that he had not imputed any fraudulent motive to Mr. Lawes, but had said the experiments were imperfect.' But on the 29th of April, Mr. Ker Seymer moved that the analysis of evidence appended to the Report of

Mr. Ellis founds his valuation of sewage on the analyses which Professor Way disclaims, and his system of application on the reports of the late Board of Health, published in 1852, before any towns except Edinburgh had used sewage, and when Mr. Edwin Chadwick, the real editor of these reports, hoped to confine the water-supply of London to 12½ gallons per head. The only witnesses he quotes are Mr. Philip Skinner Miles, Mr. Westwood, the bailiff of the Norwood Schools, and Mr. Alderman Mechi.

Mr. Ellis appeared before the Metropolitan Board without any survey, and without any engineer to support his calculations; his only assistant being a Mr. Bowick, who formerly was secretary to a scheme on precisely the same principles, devised by Mr. George Shepherd, a civil engineer, which fell through.

Mr. Ellis proposed to take in hand all the sewage on both sides of the Thames; to pump it *back* from the outfalls on the Thames to two reservoirs of twelve and seven acres each, to be constructed on summits as high as Hampstead and Shooter's Hill, 460 and 420 feet high. He first named those hills, but the resident

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the Select Committee on Sewage, 1862 (printed 1863), be cancelled: and it was cancelled without a division. Dr. Brady drew up this one-sided analysis, in which, in Mr. Ker Seymer's words 'he passed by one whole class of evidence, and gave prominence to the evidence of persons who agreed with him.' Next to a reprimand at the Bar of the House, this was the most severe censure that could be passed on a Member of Parliament, but Dr. Brady received it quietly, and rose and abused Mr. Lawes again.

population objecting, he left the sites of the reservoirs a blank. There is no elevation sufficient for the purpose, after passing Hampstead, nearer than Harrow, and Harrow is as likely to object as Hampstead.

From these summits he proposed to irrigate by gravitation a tract of 500,000 acres, and for this purpose to lay works over 1680 square miles, at a cost which even he estimates at not less than £4,000,000 sterling. This wide distribution is founded on the theory that no crops would require a dose of more than 500 tons per acre per annum, at a cost of 2*d.* per ton, or £4. 3*s.* 4*d.* per acre; and further (as a large proportion of this half-million acres would be arable land, and the largest proportion a stiff clay soil), that the sewage of London was a profitable manure for all crops on all soils.

For the effective distribution of quantities of sewage not exceeding 500 tons, distribution by pipe, jet, and hose would be indispensable. It would therefore be essential that the farmers or the landlords of the half-million acres invested a further capital of at least from two to three millions in pipes and apparatus. Wherever steam cultivation has been introduced, it would be necessary to lay these pipes very deep, at a proportionate increase of expense.

The cost of working this gigantic watering apparatus, Mr. Ellis estimated at three hundred thousand pounds a year. On the other side, confident in being able to retail the hundred million tons at 2*d.* a ton, he calculated on a net profit of one million four hundred thousand pounds, which he proposes to divide with the Metropolitan Board—that is, with the ratepayers. The promise of a net revenue of seven hundred thousand a year, to be realized from the filth of the sewers, produced a great effect on the minds of the ratepayers, who heard of the value of sewage for the first time from the literary and oratorical advocates of Mr. Ellis; and when this brilliant promise of income was accompanied by a statement, that a band of base manufacturing capitalists were conspiring to rob the 'poor overtaxed ratepayers,' it may easily be imagined that a sensation of no ordinary character was produced; Dr. Brady, M.P., on several occasions explained these sewage prospects to parish meetings, called for the purpose; and resolutions in favour of the Ellis plan (since inserted in a Blue Book) were passed very unanimously.

We happened to be present at one of these parish meetings; including reporters and Dr. Brady's staff, there were under thirty persons present.

Mr. Ellis asked the Metropolitan Board for an absolute concession of the sewage. He produced a letter from Messrs. Pain, Eddison, and Co., attorneys, Leeds, stating that on his obtaining this concession they were prepared to advance £60,000 for preliminary expenses. The concession obtained, a survey of the 1680 square miles was to be made, plans deposited, and an application made to Parliament, a measure involving a deposit of £200,000. Mr. Ellis estimated that these operations would occupy two years, and he also sanguinely estimated that three years would be sufficient for executing the engineering works.

Let us see how the balance of evidence stood, on which the Metropolitan Board was required to accept a scheme resting on the credit of a person without practical or scientific knowledge,—a scheme admitted to involve at least five years of time and six millions sterling of capital, and resting all its chances of profit on finding some hundred of clay-land farmers, who, having never previously dreamed of using liquid manure, would yet be ready to pay £4. 3*s*. 4*d*. an acre for London sewage, and spend at least as much per acre in fitting their farms to the 'jet and hose system.'

Evidence.

For Universal Application to all Soils and all Crops in Dressings under 500 *tons an Acre, at* 2*d*. *per ton.*

Alderman Mechi, '2*d*. per 'ton at certain seasons,' see p. 48.

Mr. Westwood (who applied 1500 tons of liquid manure, not sewage, to Italian rye-grass), see p. 45.

Philip S. Miles, Esq. (who declares that he is no authority on the profit-and-loss part of the question, and always used strong liquid manure), see p. 43.

For Application to Light Self-drained Soils, to Natural and Artificial Grasses, in Dressings of 1500 *tons and upwards.*

Chemical.

Professor Way.

Professor Voelcker.

J. Bennett Lawes, Esq.

Engineering.

Robert Rawlinson, Esq., C.E., Officer of the Board of Health.

J. Fenton, Engineer to the Croydon Board of Health.

Agricultural.

The Earl of Essex.

J. Miller, Esq., owner of the Craigintenny Meadows, Edinburgh.

Sir Joseph Paxton.

J. C. Morton, Esq.

*Edward S. B. Congreve.

*J. Archibald Campbell, Esq.

Cuthbert Johnson, Esq., Chairman of Croydon Board of Health, Commissioner of Metropolitan Sewers, 1852.

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* Tenants of Rugby sewage farms.

It seems hard that more and better witnesses could not be found in favour of a plan which was to give the metropolitan ratepayers seven hundred thousand pounds a year.

But Mr. Ellis has a theory which accounts for the perverseness of the chemists, agriculturists, and engineers, —a theory broadly stated in his pamphlets and broadly insinuated in his evidence. It is shortly this,—'The 'manufacturers of artificial manures are in a conspiracy 'to discourage the utilization of sewage, because it would 'be a rival to their dry portable manures. Mr. Lawes 'is at the head of this conspiracy, being one of the principal artificial manure manufacturers. Mr. Lawes has, 'therefore, intentionally mismanaged the experiments 'undertaken at Rugby at the request of the Royal Commission, with the view of depreciating the value of 'sewage. He and his co-conspirators have also bribed 'or otherwise "got at" all the witnesses hostile to Mr. 'Ellis's views; nay, further, that these conspirators are 'capable of poisoning sewage in order to discourage 'farmers from using it.'

For instance, being asked how he can account for the Duke of Northumberland's tenants near Alnwick declining, after two years' experience, to pay the cost of pumping the town sewage on their land (see Appendix), H. C. ommittee 2090. Mr. Ellis answered, *I do not know whether the sewage 'might not have been poisoned before it reached the land. 'I could poison any sewage. The Duke of Northumber-'land holds a very high position as an agriculturist, and 'if he threw the weight of his name and influence into the 'question, it would be solved at once; and it would there-'fore pay the artificial manure men to poison the sewage.'* (See Appendix B.)

In another place (1776 and 2417) Mr. Ellis says that the dealers in artificial manure have an interest in running down the value of sewage. That (2423) Mr. Lawes himself got up a testimonial from the agriculturists to himself. At 2422, that ‘Mr. Lawes has no ‘right to make any pretensions to science.’ At 2463, he says, ‘The honourable member cites against me ‘practical experiments which are conducted by a man ‘whose interest is manifestly opposed to the utilization ‘upon my system (?).[*] It is an outrage against common ‘sense to say that the greatest manufacturer in the ‘country, a man who clears £40,000 or £50,000 a year ‘by the sale of artificial manure, should be permitted to ‘carry on experiments at the expense of the nation to ‘test the value of this rival manure.’

And this insinuation, which is repeated again and again in a more offensive manner in pamphlets and newspaper correspondence, has received the sanction of Baron Liebig, who says, in a letter to Mr. Ellis, ‘You ‘must be prepared for the opposition of the artificial ‘manure manufacturers, and particularly the manufac‘turers of superphosphate of lime.’[†]

The answer to this charge of conspiracy and deliberate fraud is as complete as compact.

1. It is not the interest of artificial manure manufacturers to discourage the use of sewage.

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[*] Qy. Mr. George Shepherd's Prospectus.

[†] It is pitiable to see a really great philosopher so carried away by one of the meanest of passions—envy. Baron Liebig hates the English people, the English farmers, and Mr. Lawes, for the same reason, because they have been only too successful, as a nation, as cultivators; and as a manufacturer, Mr. Lawes manufactures wheat and root manures, which, unlike the Baron's famous patent mineral manures, grow excellent crops. The British farmer, with characteristic stolidity

2. The experiments of one manufacturer of superphosphate, Mr. Lawes, have done more to encourage towns to utilize their sewage than all the vague statements and wild promises that had previously been published.

As to the first proposition, the chief trade of the principal London manure manufacturers is done with counties like Norfolk and Suffolk. One great establishment,—not Mr. Lawes's—does more business with Scotland than all the metropolitan part of Essex and Middlesex.

According to Liebig himself, the chief deficiency of sewage is phosphoric acid. The bones of meat do not pass into the sewers. He declares that the addition of superphosphate of lime will double the value of sewage. Hence it is clear that the wide utilization of sewage will create a new market for the artificial manure, on which Mr. Lawes and his fellow-conspirators say 'The Blood Manure Company' and the London Manure Company make their greatest profit.

As to the second proposition, if Mr. Lawes was rogue enough to falsify the experiments entrusted to his care by the Earl of Essex and his fellow-Commissioners, he missed his aim if he did not make out that sewage absolutely worthless, but instead of this he showed clearly how a single acre of land could be made to earn a rent of £25 a year.

The manure manufacturers, whom Mr. Ellis considers

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in opposition to the Liebig theories, purchases the manures of Lawes and other manufacturers of the same class of fertilizers, and the British merchant braves the indignation of the Professor, and purchases and imports from Germany and elsewhere, linseed oil-cake, the bones, and other cattle food and material for making portable manure. For these high crimes and misdemeanours Baron Liebig, in his most recent work, terms England '*a vampire hanging on the breast of Europe.*'

capable of a penal crime in poisoning sewage, have not only made a miserable hash of experiments, which ought, according to Mr. Ellis, to have proved that to use sewage was to ruin land, but they have purchased the evidence of a most provoking set of witnesses. Sir Joseph Paxton and Mr. Miller, Mr. Rawlinson and Mr. Campbell, Dr. Voelcker and Professor Way, all agree in a most aggravating manner that sewage is of value, and will pay, if put on the right place, to the right crops. Unfortunately, neither the place nor the crops will suit Mr. Ellis's theories.

The Metropolitan Board had to choose between a well-matured plan, based on principles approved by engineers, agricultural chemists, landowners, and tenant farmers, who had all had special opportunities of studying the use of sewage, and sanctioned by the precedents of all the towns where sewage had been utilized, and a project founded on the theories of a defunct Board of Health, a mere outline of assertions without details, unsupported by a single practical or scientific witness of any reputation in the chemical, engineering, or agricultural world.

The Metropolitan Board, after years of close investigation, has selected and approved the plan of Messrs. Napier and Hope, and we have no doubt that Parliament will confirm and the public voice justify their decision. The Board, like other public bodies, has its cavillers and detracters—hostile critics whom nothing can satisfy; but it has earned and deserves the confidence of the Metropolitan public by the manner in which it has carried out the Main Drainage, and designed and commenced the Thames Embankment, as also for the careful and admirable report published on the

8th of November last, on the application of sewage at Rugby, Croydon, Carlisle, and Edinburgh, short extracts from which, as to Croydon and Edinburgh, are annexed:—

Croydon.

'The population whose excreta flow over this land is about '17,000 in number, from which 3000 tons per acre per annum 'are said to be derived; one-tenth of the land is under irriga'tion at a time, and each acre is under treatment 36 days in 'the year. The sewage takes about five hours in flowing over 'the land from the time of leaving the inlet; that period is 'sufficient entirely to deodorize it, and to enable the herbage 'to abstract from it the fertilizing salts; after the process has 'been continued two or three days, it flows off nearly tasteless, 'colourless, and inodorous. The greater portion of the farm 'is sown with Italian rye-grass, which requires re-sowing every 'three years and appears to produce the largest results, but 'some parts are still in natural pasture. It is rented by the 'Croydon Local Board at £4 per acre, and is sub-let to Mr. 'Marriage at £5 per acre, so that the Local Board obtain an 'improved rent of £250 per annum, which goes in reduction of 'their local rates. Your Committee could not ascertain the 'exact weight of grass produced. *It is cut four times a year, 'and each cutting sells for about £8 per acre;* it is used 'chiefly for stall-feeding dairy cows.'

Edinburgh.

'At Edinburgh they witnessed the beneficial result of many 'years' experience of the profitable application of sewage to 'sea sand. . . . There are parts of the land which are said to 'have been irrigated 200 *years ago*, but the greater area has 'been under treatment only about thirty-five years; *it was 'then sown with a mixture of grass seeds, and has never since 'been re-sown. The land near the shore was originally not 'worth 5s. an acre, it is now assessed at £22 per acre.*'

CHAPTER VII.

CONCLUSION.

In the examination of this important question, which is one of national interest, as the principles involved and their application, in the utilization of the Sewage of the Metropolis, will be adopted, more or less, by the municipal authorities in all the cities and towns of the United Kingdom, attention has almost exclusively been directed to the practical value of sewage in the abstract, and to the conditions essential to its proper utilization. Yet these remarks should not be concluded without a brief reference to the very different financial results to be expected from the scheme for the northern side of the metropolis of Messrs. Napier and Hope when contrasted with that of Mr. Ellis.

Mr. Ellis's project would involve an outlay by his company of from four to five millions, and by the agriculturists of upwards of two millions more, to be expended almost entirely in iron pipes of small diameter, and in valves and meters, all of which would undergo *rapid decay from oxidation*, and could not possibly be cleaned from the accumulating deposits which must in a short time obstruct the passage of the sewage, and render the valves and meters absolutely useless.

Under the scheme of Messrs. Napier and Hope, for an outlay of £2,100,000, a ten-foot culvert will be constructed, calculated to endure, unimpaired in efficiency, for ages, and carried at such a level as to command an area of 80,000 acres for irrigation by gravitation. By the proposed reclamation, 7000 or 8000 acres (in the first instance) of freehold land will be added to the cultivation of the country, worth under sewage treatment £30 per acre of annual rent, and of the capital value of from £4,000,000 to £5,000,000 sterling. By the natural action of the tidal currents, the foreshore of the 8000 acres just reclaimed will gradually shallow up, and after a short period, it will be practicable to reclaim at moderate cost another belt of sand of equal extent; and should the Government in time cease to require a tract of land at Shoeburyness for artillery practice, a further considerable area would be available for the reception of the London sewage on the north side of the Thames, and would equally be convertible into freehold land worth £400 to £600 per acre.

Should it turn out, contrary to present experience, that sewage can be profitably applied by pumping and by jet and hose to ordinary agricultural lands, there are further thousands of acres along the line of the sewer available for its reception, and from which the full practical agricultural value would be equally obtained upon that system.

APPENDIX A.

LIST OF TOWNS WHERE SEWAGE HAS BEEN APPLIED TO AGRICULTURAL PURPOSES.

	Population.	Acres.	Crops.	Other Information.
Alnwick	6,400			Use discontinued.—Farmers refused to pay the cost of pumping.
Croydon	20,000	250	Italian rye grass	Pays the town a profit rent of £1 an acre. Applied by gravitation and open surface drains.
Carlisle	22,000	70	Grass	The tenant makes a profit of nearly £100 a year. Applied by gravitation to open irrigation by iron troughs.
Edinburgh......	80,000	270	Grass and Italian rye	The landlord makes a rent of from £22 to £40 per acre. Applied by open surface drains. Hose and jet on a small part, tried and discontinued.
Malvern.........	4,000	50	Grass	No rent to town. Applied by open surface irrigation; no exact information as to profit, but a good result.
Tavistock	6,000	95	Grass	No rent paid. The result supposed to be profitable. Applied by gravitation and open surface irrigation.
Rugby	8,000		Grass and Italian rye grass	£50 a year paid to town. 400 acres piped; the tenant of half the estate applies all to 12 acres of Italian and natural grass. Use of hose and jet abandoned.
Watford.........	4,000	7	Italian rye in spring and summer	£10 a year paid to town by Earl of Essex. 210 acres were under-piped; hose and jet are partly used.
,,	,,	35	Park grass in winter.	
Worthing	7,000	42	Grass	Open surface irrigation is to be employed; not yet at work. No rent.

APPENDIX B.

Memorandum as to the use of Town Sewage at Alnwick, Northumberland, furnished by the Bailiff of the District, and forwarded to Lord Robert Montague by the Duke of Northumberland.

THE town of Alnwick having been systematically sewered, it was thought desirable to ascertain by experiment the value of the sewage for agricultural purposes, and irrigation works were carried out and prosecuted by his Grace the Duke of Northumberland during six years.

The operations were detailed in a paper prepared for the Newcastle Farmers' Club in 1862, in which year the trial was given up, because the occupiers of land thought it did not pay, although for the latter three years the Duke bore two-thirds of the working expenses; the pumps and pipes in full repair were left, with leave to the tenant on whose land they stood to use when he chose, but he has never done so.

There is no doubt that the diluted state of the sewage was the cause of failure; the situation, grass land on a sandy subsoil, was favourable, but the cost of pumping was too great to obtain a commercial return in produce. Had the outfall sewer allowed application by gravitation, the result would probably have been more satisfactory.

In a preliminary experiment by gravitation, the expense was only 15*s*. per acre, including the cutting of distributing channels, although the quantity applied was very large.

In consequence of the serious visitation of cholera to the town of Alnwick in 1849, steps were taken to bring the place under the control of the General Board of Health, and an inspection of the district was made by Mr. Robert Rawlinson, one of the inspectors of that Board. The result of his report was the formation of a Local Board of Health for the townships of Alnwick and Canongate, which proceeded to make arrangements for systematically sewering the town and supplying the inhabitants with water. These operations were carried out in 1852 and 1853. During their progress difficulty and discussion arose as to the best mode of getting rid of the sewage, *stimulated by the publications of the General Board of Health, which set forth in glowing colours the advantages of utilizing the material, either by precipitating the solid contents or applying the liquid direct to the soil.* Under the directions of his Grace the Duke of Northumberland, careful inquiries were made as to the various works of the kind which had been brought into operation; and though none of them bore directly on town sewage under the circumstances of Alnwick, it was hoped information had been obtained sufficient to guide the maturing of a plan for applying Alnwick sewage to the growth of crops. The townships of Alnwick and Canongate (forming, with slight exceptions, the town of Alnwick) contained, in 1851, 6,393 people. In 1861 the population had only increased one hundred. The whole sewerage of the town is concentrated in one outfall; but, from the peculiarities of the site, it had to be delivered at a low level, a few inches above that of the river Aln, and not available for application to the surface by direct gravitation. Any scheme, therefore, implied the cost of pumping. Mr. Rawlinson estimated the quantity at 100,000 gallons in twenty-four hours, and to lift such a quantity required very powerful machinery.

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On the 24th July, 1855, the wind-bore and pumps were successfully tested, but the regular system of irrigation pipes was not got into play until the autumn, and interruptions from accidents to machinery prevented any systematic application of the sewage until the spring of 1856. Much of this year being cold and wet, it was unfavourable to the experiment. Still the results were considered, on the whole, satisfactory, apparently evidencing the valuable nature of such a resource in a dry spring and summer. The following notes were drawn from personal observation, and the statement of the tenants at the time:—On Denwick Waterside Farm there were about fifty-four acres irrigated during thirty-two days, giving, on a calculation that the pumps raised 48,000 gallons per day, an application of 28,980 gallons per acre. The pasture land, about forty-four acres, did not, in consequence of the continual rains, show such marked improvement as was expected, but it was observed that *both cattle and sheep gave a preference to the portion irrigated* three or four days after the operation. A small field on this farm was mown for hay. It was twice watered, and was grazed by cattle up to the 22nd May, being mown the beginning of August, when it produced about three tons and a half per acre, fully a ton per acre more than the field would otherwise have produced, besides keeping six large oxen up to the 22nd of May. About one acre and a half of haul-land were sown with Italian ryegrass, which was three times cut, and, with the aid of a small quantity of bean-meal, fed off eight head of cattle. A limited extent of land under turnips and barley was also irrigated, but we cannot state the exact results. Turnips improved greatly; they made a rapid growth after being irrigated; and, doubtless but for the wet season, the advantage would have been more evident. A larger area would have been watered but for the fear that the excess of liquid, artificial and natural, would drive the plants to seed instead of increasing the bulbs. As to the barley, it is impossible to give a fair report, it was so much laid and injured by the continuous rains, which had so serious an effect on the harvest generally in this neighbourhood.

On Bridge End Farm four days were spent in irrigating about eight acres, which the tenant selected as the bare parts of the field; the result was that one part of the field was as good as the other, but being a wet season, favourable to this sandy soil, no correct conclusion can be drawn.

On Golden Moor Farm twelve or thirteen acres were irrigated (five acres of new land hay, and the rest pasture) without any marked difference. It happened to be heavy rain at the time of application, and the tenant observed the sewage running off by the drains, but whether materially changed in its component parts or not was not ascertained.

On the Pasture Farm about forty acres were done, the result being generally good. Four acres were mown for hay, in which there was improvement, but no account of the quantity was kept; the remainder was in pasture, and the tenant considered it enabled him to keep a score of sheep more than usual. Most advantage arose from the application early in March, whereby a good spring of grass was ready in the early part of April for the ewes and lambs. During the second year, 1857, the sewage was pumped for seventy days over 118 acres, averaging 28,475 gallons per acre.

On Waterside Farm—On Clover Seeds.—The locks, sixteen acres, twenty-five days, equal to 75,000 gallons per acre, cut three times about six feet of grass, but was not thick in bottom; supposed in consequence of the Clayport iron-water being used to flush the sewers for some weeks in the spring, while the clover was tender, without our being apprised, and consequent injury. On oats, North Wood meadow, six acres, four days, equal to 31,000 gallons per acre, once over; bog land which readily burnt in hot weather, and the crop would all have gone off but for irrigation; will probably yield six old bolls per acre. On old grass for pasturage,—grass banks, twenty acres; well close, five acres; bog close, ten acres; in all, thirty-five acres, eighteen days, equal to 30,400 gallons per acre: result,—good effect, but not marked.

On Golden Moor Farm.—On clover seeds, five acres, four days, equal to 34,500 gallons per acre; on seed land, two acres, one day, equal to 24,000 gallons per acre: on old grass land, twenty acres, three days, equal to 7200 gallons per acre. The tenant thinks there was no difference in the crop, as the application was nothing but water; has had as good from same land without any irrigation.

On Demesne Pasture Farm.—On old grass land, twenty acres, ten days, equal to 24,000 gallons per acre, once over; little or no advantage this year.

On Bridge End Farm.—On old grass land, fourteen acres, five days, equal to 17,144 gallons per acre: part done twice over, was hayed. Tenant says the latter part of the field was increased in quantity, but in consequence it was laid and turned yellow at the bottom before it was cut, and therefore made inferior hay; the poorest land gave a fair crop, but nothing equal to the expense of application.

These results are not so satisfactory as was expected. There was no long duration of dry weather this season to develope the peculiar value of mere irrigation, and the extremely diluted state of the sewage seems to have prevented appreciable manure benefit, although in some cases the quantity applied was very large. The facilities afforded the town of increased water-supply tends annually to increase this difficulty. At first twelve gallons per head per day was estimated as the town consumption; it is now twenty-three gallons, and it is intended to bring a large additional quantity of water from Rugley Burn. The following figures, as showing the unexpected and excessive dilution of the sewage, are worthy of being recorded:—The original water-supply to the town of Alnwick was estimated at 12 gallons per head for 6000 people, or, in twenty-four hours, 72,000 gallons; but Mr. Rawlinson said the sewage might probably give 100,000 gallons. By the recent application of the Local Board, it appears that, while the supply is yet deficient, they consume 23 gallons per head, or 138,000 gallons; while, at the same time, there has been, from May to October of this year, liquid issuing from the sewer at the rate of 140 gallons per minute, or, in the twenty-four hours, 201,600 gallons—excess more than water supplied, 63,000 gallons. Of this quantity our machinery cannot lift more than 50,000 gallons per working day of ten hours.

In 1858 the sewage was only pumped for fifty-five days, and without any decided effect. This we attribute to the excessive dilution of the liquid. There were no marked results on the grass land at Waterside, when the application was in the ordinary way of four or five acres per day, or 10,000 gallons per acre; but by *forming a trench* along the bank of a field, upwards of 90,000 gallons per acre *were applied by gravitation, with a large increase to the pasturage, which also was preferred by stock, the sheep feeding close to the running liquid without any ill result.* Half an acre of Italian rye-grass received the pumping of eight days, or at the rate of 768,000 gallons per acre; and after 24th May it produced three large crops, equal to about eight feet in length of grass, which was used for soiling cattle.

From the foregoing statements it seemed evident that excessive dilution had proved the bane of the experiment.

When operations first commenced there was not liquid to keep the pumps going steadily all the day; now the quantity before calculated on per day should be more than doubled, of course materially affecting the important question of cost per acre. This year the expense of applying averaged 10*s.* per acre, but the Italian rye-grass would cost for the half-acre £5. 3*s.* 6*d.*

. . . .

The result is not favourable, partly from the conflicting interests of the tenants preventing them working together, but chiefly from loss of time in wet, snow, or frosty weather, fracture of machinery worked at a high pressure, and unsatisfactory results.

TABULAR STATEMENT OF TIME.

	1859.	1860.	1861.	Average.
Days worked in each year	104	137¼	127¾	123
,, lost by weather	96	90	115¾	100*
,, lost in repairing machinery	84	78¾	48½	70†
,, when engine was employed on farm works	8	7	19	11‡
Sundays and holidays.....................	48	52	54	52

From the foregoing figures it appears that the best average we could get was 123 working days out of the year, costing £1. 2*s*. 10*d*. per acre per day. The operations were entirely upon grass, and to justify such an expense ought to have given an extra ton of hay, or its equivalent in pasturage. As to this, Robson says that in 1861 he had a better crop, but nothing like half a ton. In 1860, irrigating in November and December set the grass growing in February, and the frosty cold weather of March finished it off for the rest of the year. In 1859, being rather late in putting on, the grass was beaten down, and never rose again. He thinks the money it has cost him expended in guano would have given much more satisfaction. Bradley and Davison are equally unfavourable in opinion, the latter stating that there was some benefit in dry weather, probably not more than pure water would have given. He left some ridges in hayfield, but when harvest time came saw no difference in the crop. Thomson, of Waterside, has been throughout most zealous, but his accounts are not greatly different from others. With regard to the land recently laid to grass, he observes, "very fair improvement," and "looked well in the spring;" some light grass land "improved." On a portion of the haugh during last year he pumped two days per acre, and "as yet there is no evident difference from the rest of the field."

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* In 1859-60, long continuance of snow and frost; 1860-61, a favourable year, yet 90 days lost; 1862–63, a very wet year.

† Lessening in each year.

‡ Thrashing corn, etc.

In our limited experiments the turnips were much "trashed" in manipulating the hose, and the soil torn up by the force of the liquid. On a loose, sandy, or gravel soil, to turn a rivulet upon it would wash the seed away bodily. This tends to limit the application to grass land, and even in this satisfactory results will only be obtained when the market enables a large quantity to be cut for green food.

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